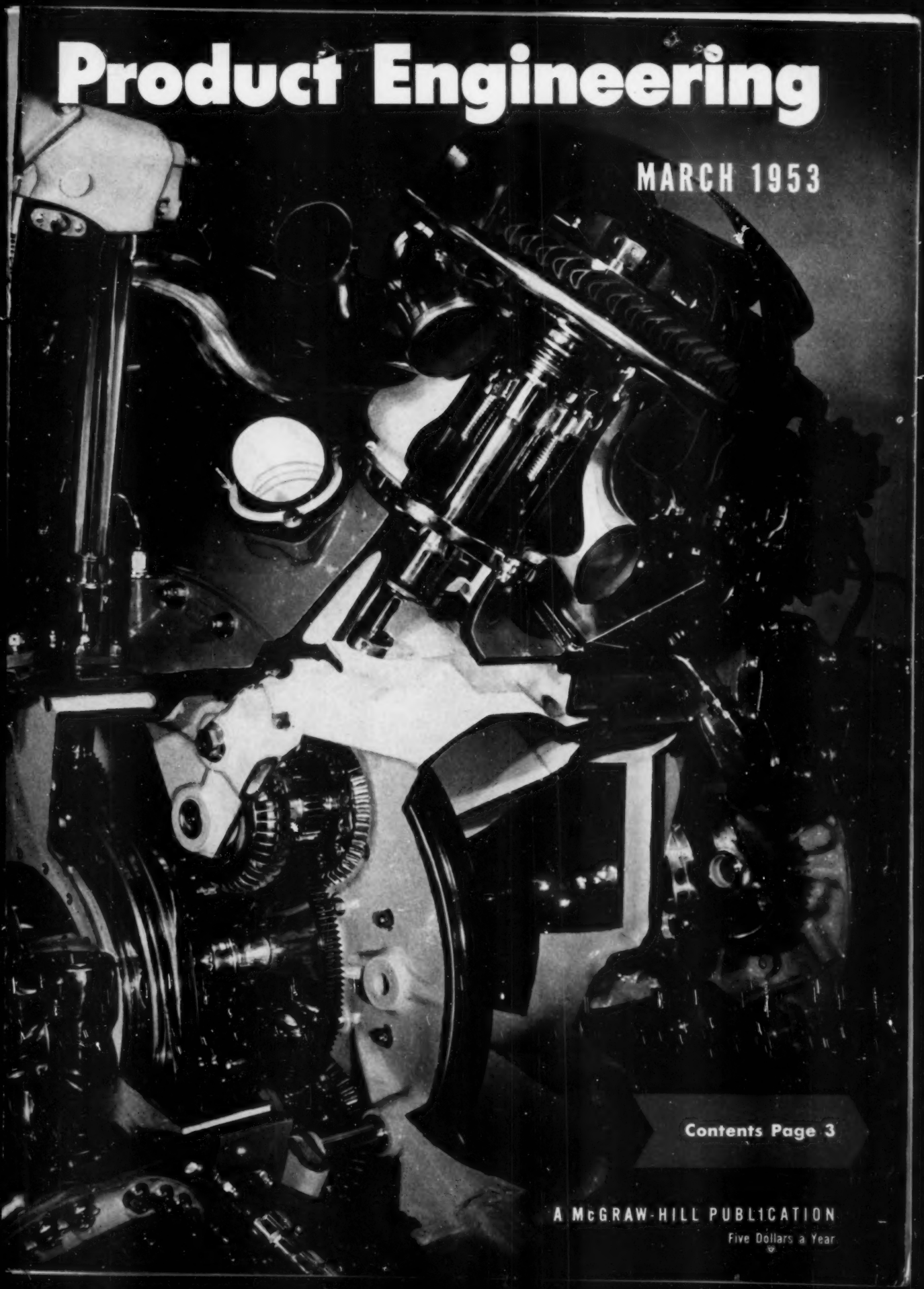
Product Engineering

MARCH 1953



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A McGRAW-HILL PUBLICATION
Five Dollars a Year

Ringing Success . . .

SHARON* DEVELOPED SPECIAL STEEL MAKES TELEPHONE BELLS RING TRUE

Shortages of critical materials often force the use of substitutions. This happened in the telephone industry, where recently a manufacturer of phone bells — cut off from his supply of copper and brass—began looking for a suitable replacement.

Steel was still on the unrationed list, but bells formed of available steel didn't produce the required ringing tone. That is until Sharon Steel was asked to develop a steel of a temper that could be formed into bells with the required tone.

Sharon engineers went to work and in a short time developed a steel that fills the bill so effectively it is expected to become standard regardless of the availability of the materials formerly used.

*Specialists in STAINLESS, ALLOY, COLD ROLLED and COATED Strip Steels.

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Sharon, Pennsylvania

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For information on Titanium contact Mallory-Sharon Titanium Corp., Niles, Ohio

SHARONSTEEL

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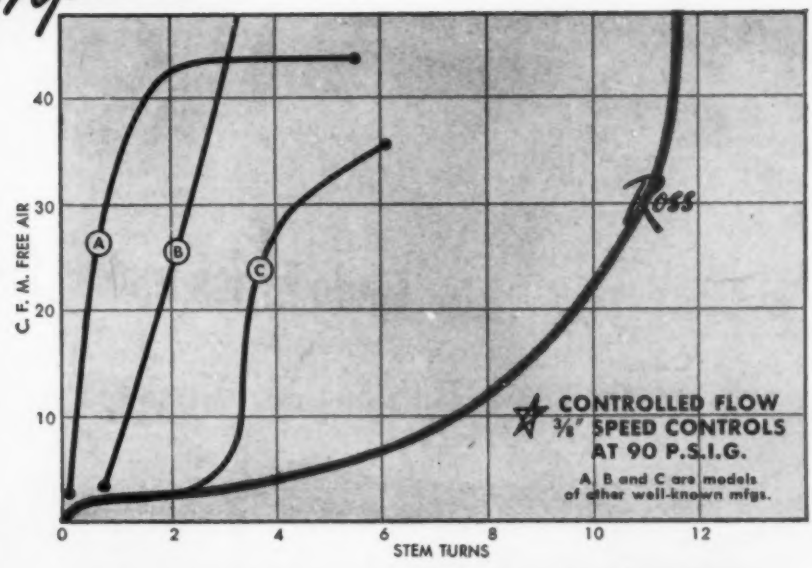

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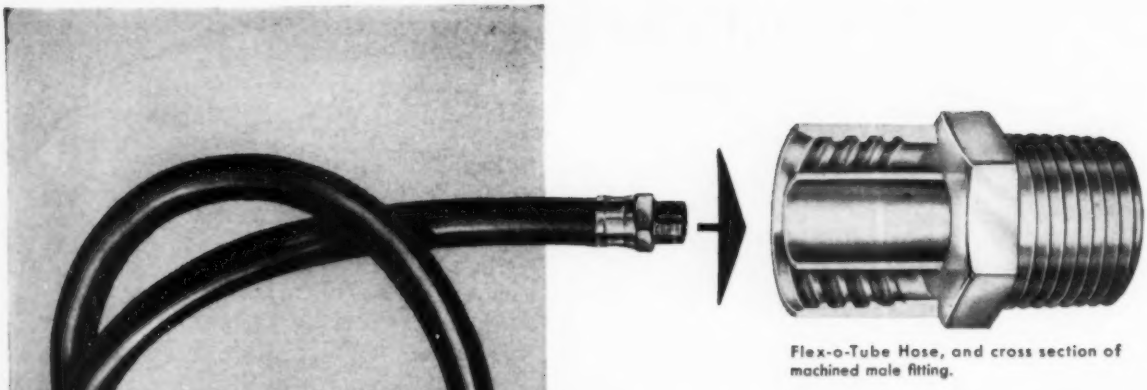
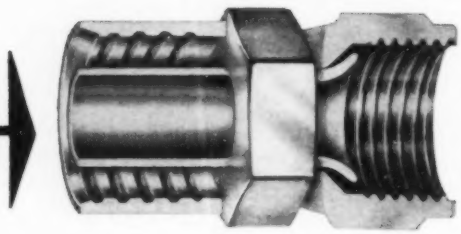


Flex-o-Tube Hose, and cross section of machined male fitting.

FLEX-O-TUBE ...finds brass makes fine fittings



Cross Section of machined and flared female fitting.

For quick, accurate and economical machining, free-cutting brass rod is preferred by many companies, such as Flex-O-Tube, Division of Meridan Corporation, Detroit, Mich. This company makes hose assemblies and fittings to conduct air-oil-water-gasoline and hydraulic power for the automotive, farm implement, machine tool and aircraft industries. Some of these hoses have a minimum bursting pressure of 20,000 pounds per square inch, which gives an indication of the tightness required, which can be obtained only by strength and accuracy.

Flex-O-Tube has found six points of superiority for brass over other metals, as follows:

1. Brass "flows," or is ductile, so that no cracks result during the crimping operation required to fasten the fittings to the hose.

2. Ductility and strength inherent in brass act to provide a superior seat to fittings designed to control fluid flow. Competitive metals are either too hard or too soft to give positive closing and tend to leak.

3. Where the design of the fitting is intricate, necessitating removal of considerable metal by machining, the automatic screw machines can be run faster with free-cutting brass rod.

4. Brass has a high scrap value, and the scrap sold back to the mill increases brass supplies.

5. The break-even point between brass and other metals is especially favorable to brass in the sizes of rod that Flex-O-Tube buys.

6. Customer preference is for brass, which is universally recognized as a quality metal. Hence brass fittings are more readily sold, and in fact often are specified regardless of size or price differentials.

Included in the Flex-O-Tube operations are machining, flaring, crimping, and annealing to assure the proper ductility for flaring and crimping.

Revere is an important supplier of brass rod to Flex-O-Tube, and has also collaborated with this customer through the Revere Technical Advisory Service.

If you wish information about brass and how one or more of the Revere brasses can add to the economy and saleability of your product, get in touch with the nearest Revere Sales Office. See your telephone directory or write direct.

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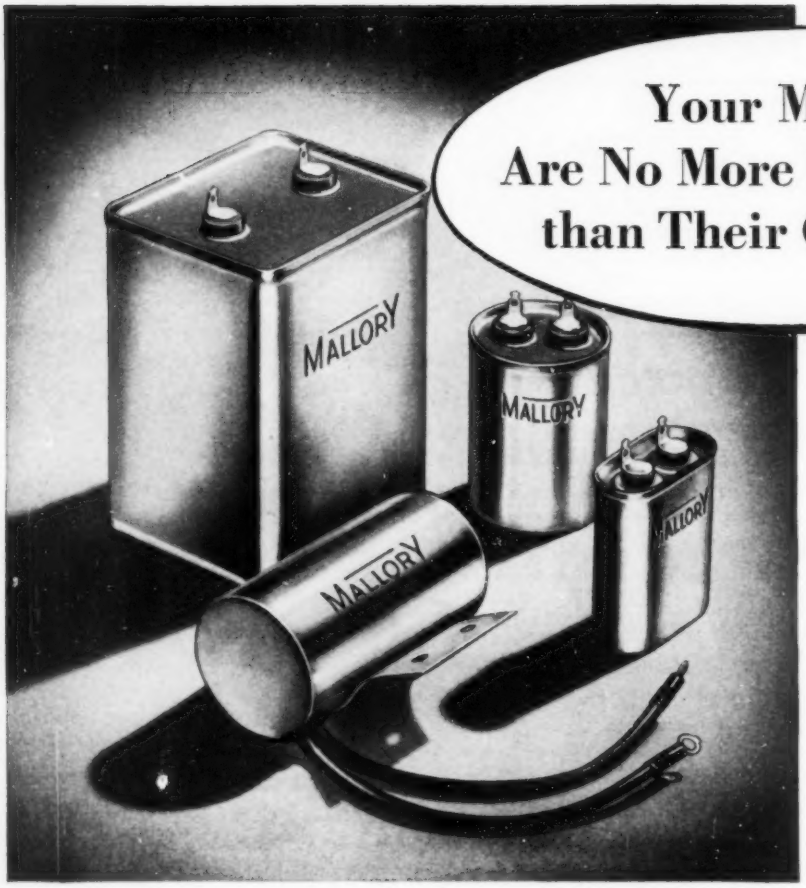

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Highlights

When requesting further information from companies and organizations mentioned in the items below, confusion can be avoided by referring to the issue of Product Engineering in which items appear

NONMETALLIC MATERIALS

GREATER ABRASION RESISTANCE and high resistant to attack by ozone are promised for rubber products. Dupont chemists new rubber-like material "Hypalon" is highly resistant to attack by ozone, a primary cause of deterioration of rubber exposed to air. When compounded with rubber it imparts its ozone resistance to it. U. S. Rubber Co. Buffalo, N.Y. has made GR-S synthetic rubber extra tough by adding resin chemicals to it. 30 percent more abrasion resistance is forecast.

A PLASTIC RESIN THAT BONDS ALUMINUM alloy is providing a greater strength and a 25 percent reduction in weight compared with welded and riveted structures in jet aircraft. Called Redux, and being handled by Ciba Co. Inc., the resin is a recent development of England. Smooth external surfaces, increased fatigue strength, and a reduction of production assembly time are claimed for the resin.

AN EASY-TO-HANDLE silicone rubber that bends without cracking at -120 F has been developed by G.E. Called SE-550 the rubber can be made into gaskets, seals and wire insulation for use in aircraft and ground equipment for the arctic region. The substance resists heat to 500 F and can be milled and extruded into parts that are both precise and intricate in shape.

POLYETHYLENE TEREPHTACATE called "Mylar" is a new and promising dielectric in film form. Developed by E. I. Dupont and investigated by Bell Telephone engineers, Mylar is superior to paper as the dielectric in electrical capacitors because of higher insulation resistance, temperature coefficient of capacitance and operating temperature range. Mylar is unusually strong, has a high softening temperature, and is available in very thin films.

SYNTHETIC LUBRICANTS that will be used in lubricating the aircraft turbine engines of the future are not as good today as they could be, NACA scientists report. The effects of a wide range of sliding velocities on boundary lubrication of synthetic fluids were studied. Friction data and surface-failure properties showed that a silicone diester blend, an alkyl silicate ester, and a compounded diester were more effective than the comparable diester presently being used for synthetic lubricants.

METALLIC MATERIALS

RESISTANCE TO 58 PERCENT SULFURIC acid at a temperature of 158 F is claimed for a new corrosion resistant stainless steel. Known as Carpenter Stainless No. 20; the rods have been in use for 3,750 hr. Stainless Type 316, under similar conditions, lasted about 30 hours. Test specimens were 1/2-in. square rods.

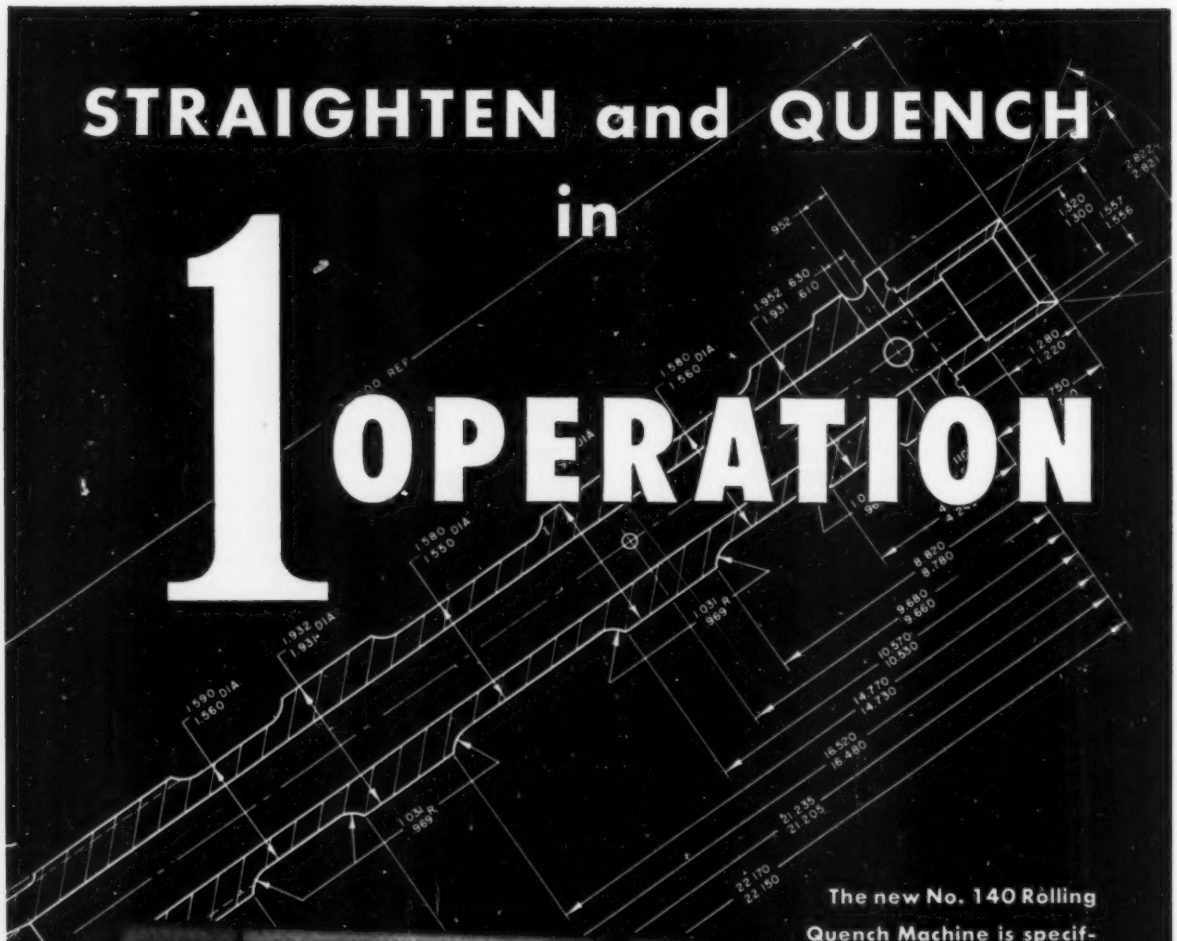
HARD FACING ALLOY that is resistant to abrasion at high temperatures, has ability to withstand attach by molten copper and improved welding characteristics are claimed for CM-199. Coast Metals Inc, Little Ferry, N.J., further report that it can be applied with any good arc welding process, will weld over itself and other ferrous materials without cracking, checking or becoming porous.

SUPER-HARD SURFACE by the action of nitrogen with steel can be produced according to Lindberg Engineering Company, Chicago, Ill. Known as Malcomizing, the process takes advantage of the chromium in the various grades of stainless as the hardening element, thus forming a hard wear-resistant surface without affecting the corrosion resistance of the steel.

HIGH DENSITY METAL using tungsten as its major constituent and having a specific gravity 50 percent greater than lead is a development of Metal Carbide Corp, Youngstown, Ohio. High

(continued on page 7)

STRAIGHTEN and QUENCH in 1 OPERATION



No. 140 ROLLING QUENCH MACHINE

The new No. 140 Rolling Quench Machine is specifically designed to do two operations at once. Straightens and quenches shafted parts simultaneously. Shafts up to 4" diameter and 40" long are quenched and straightened with a minimum of distortion. Ideal for job lots or high production.

GLEASON

GLEASON WORKS

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resistance to the penetration of radioactive rays fits it for use in screening atomic radiation. The metal is also suited for static and dynamic balancing and for applications requiring maximum weight in minimum space such as for flywheels and other inertia devices.

RATE OF WEIGHT LOSS of steel corroding normally in soil can be measured electrically without actually weighing the metal. Some National Bureau of Standards tests prove that the corrosion rate of a tank or other underground structure can be determined without visual inspection. The electrical method also measures the present corrosion rate, more important than the past rate, and does so without the removal of any inhibitor on the underground structure.

PROCESSES

DOMONSTRATION of a series of new welding materials and advanced welding techniques for arc and torch will be made in the near future by the Electric Welding Alloys Corp, Flushing, N.Y. Organic bonding agents that join metal to metal and to dissimilar materials at extremely low heats, or no heat, and without pressure will be shown. These products have been used for the bonding of titanium to magnesium to aluminum, and of these to glass, graphite, copper, rubber, asbestos, cast iron, ceramics and some plastics.

COLD-DIP corrosion protection with coatings from 0.001 in. to 0.060 in. has been developed. R.M. Hollingshead Corp, Camden, N.J., reports that a plastisol composition heated to 300 F is used and the item dipped into the solution. The amount of deposit is controlled by rate of withdrawal and by the temperature of the item being coated. For any specific plastisol, the coating thickness can be varied by slowing down the withdrawal rate or by utilizing more than one dip.

REMOVAL OF CUPROUS OXIDE after high temperature treatment without using an acid that attacks the base metal has been developed by Enthone Inc. New Haven, Conn. Ebonol "C" is used to convert the cuprous oxide to cupric oxide and this is removed by a dilute acid solution. If the oxide is heavy, the cycle can be repeated until the base surface is exposed.

RADIOACTIVITY METHODS have accelerated research on semi-conductor materials used in transistors. Sylvania Electric Products Inc., Bayside, N.Y. in cooperation with Brookhaven National Lab, Upton, L.I., N.Y. state that the electrical properties of germanium and other semi-conductor materials are dependent upon presence or absence of certain impurities. In processing, the material is first purified to a very high degree, then, in a controlled fashion, those impurities whose presence is desired are added. The amounts added are determined by standard methods of measuring the intensity and rate of decay of radioactive emission.

THE FIRST LARGE EXTRUSION PRESS is expected to start operation about June of 1953. The press, located at Alcoa's Lafayette Ind. plant, is rated at 13,200 tons and is capable of producing solid shapes 90 ft long, weighing 2,300 lb and with maximum cross-section that fits within a 23-in. circle. 75 S alloy ingots have been cast for extrusion in this particular piece of press equipment.

COMPONENTS

VACUUM CLIPPER DIODE AND RECTIFIER tube, 2 in. long and 3/4-in. O.D. is available from Amperax Electronic Corp., Hicksville, L. I., N.Y. Developed primarily for military radar applications, it shows possibilities for use in the high voltage electronic field where space requirements are critical. The diode operates under more stringent conditions than other tubes.

STANDARDIZED CIRCUITRY "PACKAGES" plug in for use in construction of electronic computers have been developed by the National Bureau of Standards. The improved system of circuity is for standardization of equipment to be purchased by the government.

INSULATION AGAINST HEAT with potential application in fields where heat and limited insulation space are factors is under development at the G.E. research laboratory. The insulation is reported to be 10 times as efficient as any now is use. A prototype, XR-10, of the new thermal barrier uses walls only 1/2 in. thick as compared to normal thicknesses of about 2 1/2 inches.

(continued on page 9)

Panel of bare 24ST Aluminum, untreated. Extensive corrosion after 168 hours in salt spray.

Panel of bare 24ST Aluminum, treated with Bonderite 710. No corrosion after 168 hours in salt spray.

Panel of bare 24ST Aluminum, treated with Bonderite 710. In excellent condition after 1008 hours in salt spray.

SALT SPRAY TESTS SHOW CORROSION RESISTANCE

ALUMINUM gets increased corrosion resistance, greater durability for paint, with BONDERITE* 710

Here's the surface treatment that practically ends the problem of corrosion on aluminum. Even on high-strength alloys, most susceptible to corrosion, Bonderite 710 protects bare metal for amazingly long periods without failure. Its performance as a base for paint is outstanding.

Bonderite 710 produces an amorphous chromate coating on aluminum surfaces. It can be applied by spray, immersion, or brush, on sheets, castings, forgings and extruded and rolled forms. It operates at low temperatures and is sludge-free.

Bonderite 710 is a liquid—safer and easier to handle, easier to use, more positive in results.

This product's performance equals (*exceeds,* in most important requirements) the government specifications for chemical treatment of aluminum and its alloys.

For bare corrosion resistance, or as a corrosion-resistant base for paint, investigate Bonderite 710 for aluminum.

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BONDERITE—corrosion resistant paint base
BONDERITE and BONDERLUBE—aids in cold forming of metals
PARCO COMPOUND—rust resistant
PARCO LUBRITE—wear resistant for friction surfaces

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

ELECTRIC MOTORS OF ULTRA SMALL SIZE are being produced to meet military specifications. The Connecticut Telephone and Electric Division, Meriden, Conn., class these motors as the smallest and the most powerful ever built. They can maintain. synchronous speeds of 8,000 and 12,000 revolutions per minute. Two models of this ingenious design are available.

NEW TRANSDUCERS that use electro-kinetic streaming potential phenomenon have been developed for the measurement of pressure, acceleration and displacement. According to the Beta Corporation, Richmond, Va, they have sensitivities comparable to piezoelectric devices but have lower resistive output impedance at low frequencies giving a superior signal-to-noise ratio. Transducers have linear amplitude ranges of 1,000,000: 1 and a useful frequency range from 0.5 cps to 30 kc. Among new applications are differential gages and hydro-phones.

TESTING

TESTS made on experimental quantities of three aluminum alloys M255, M257 and M276 indicate that a wide range of parts can be made by the powder metal technique. These Alcoa alloys have good strength and stability, and a resistance to creep at elevated temperatures. Oxidation appears to contribute to the strength of the final product. M257 shows superiority to the commercial wrought alloys at about 500 F and this continues with increasing temperature. Proposed applications include diesel and aircraft pistons, valves to control the flow of hot gases.

ULTRASONIC TESTING of small diameter thin wall tubing to locate flaws has been successfully accomplished. GE's Knolls Atomic Power Laboratory, Schenectady, reports that the testing is feasible when the shear wave is parallel to the longitudinal axis of the tubing. Best results are obtained with a one mc, one in. quartz crystal, angle searching unit.

AIRCRAFT RESEARCH INSTRUMENTS for the measurement of pressure have been developed by the Research Division of Langley Aeronautical Labs, Va. One is a miniature electrical pressure gage with accuracy within less than one percent for fluctuating and steady state pressures. The second is an instrument designed to measure pressures and integrate the results electrically. Former practice was manual integration.

NEW TEST for corrosion gives good average results and correlation with actual conditions. A test specimen either indented or scratched, states the British Iron and Steel Research Association, is exposed to a dilute solution of sulphur dioxide inside a covered beaker. Moisture is produced by an electric heater and cooling coil. The test seems to simulate attack on metal by industrial atmosphere better than the salt-spray test.

A 100-FT DROP TESTER now in operation at the National Research Laboratories, White Oak, Md. can simulate a free fall up to 100 ft at accelerations of 50 to 250g. The device requires only 10 ft vertical clearance, and because of its own base plate, does not have to be secured to the floor. Design is available to military contractors for quality control use.

THIS MONTH'S COVER

The Wright Turbo-Compound engine, conservatively rated at 3,500 hp for military service and 3,250 hp for commercial aircraft, has three auxiliary turbines, each of which extracts energy from the exhaust gases from six of the eighteen cylinders. The power recovered, averaging 18 percent or more for all ranges of flight conditions, is transmitted from the turbine wheel shaft and quill shaft through a fluid coupling to a set of bevel gears, and from there to the main crankshaft gear.

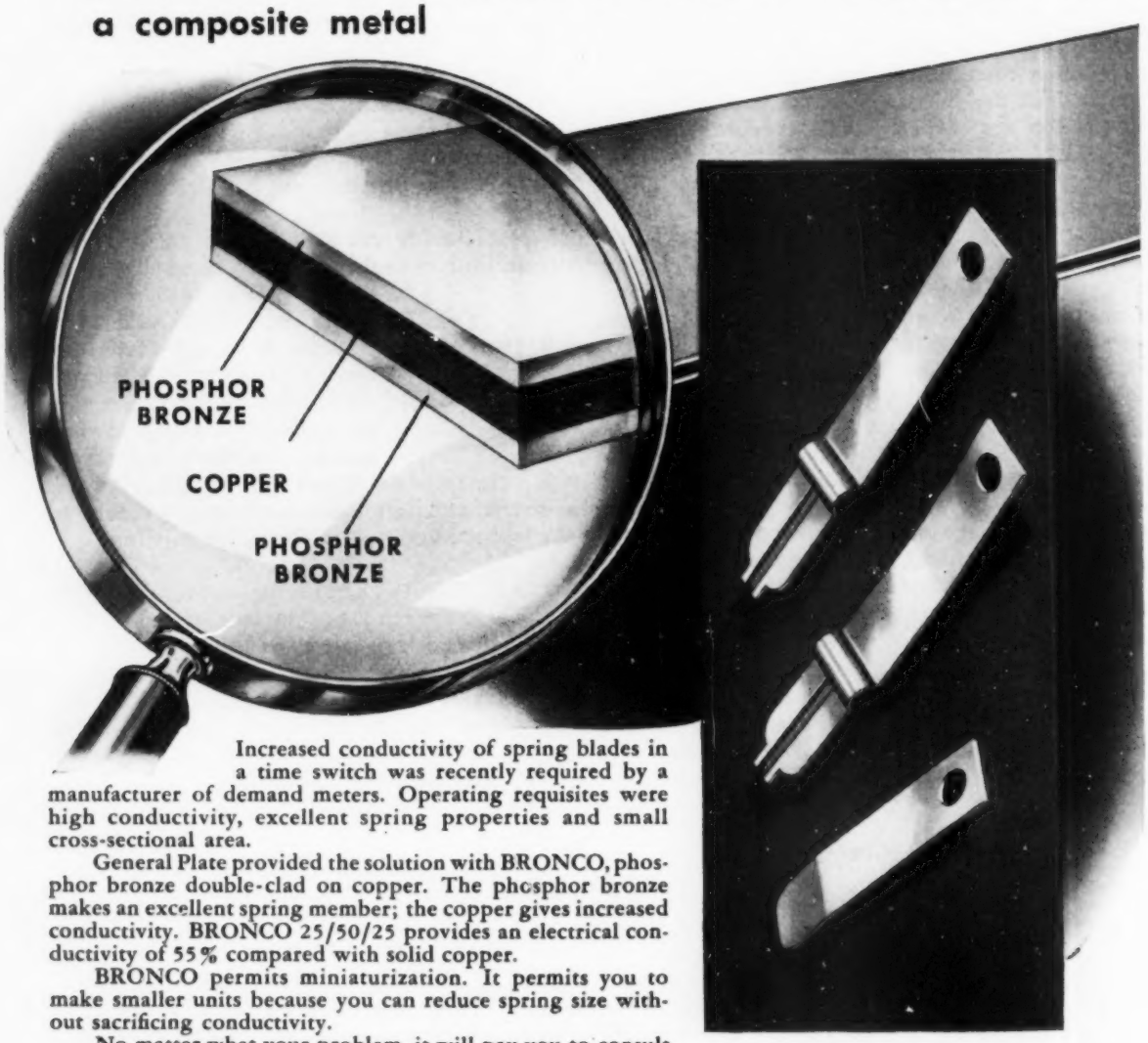
Although it has been in production for the Lockheed Super Constellation and numerous other aircraft, and is scheduled for the Douglas DC-7, the military classification on internal details has just been relaxed.

PROBLEM:

Obtain higher electrical conductivity without increasing the cross-sectional area of spring blades

SOLUTION:

General Plate provided the solution with BRONCO . . . a composite metal



Increased conductivity of spring blades in a time switch was recently required by a manufacturer of demand meters. Operating requisites were high conductivity, excellent spring properties and small cross-sectional area.

General Plate provided the solution with BRONCO, phosphor bronze double-clad on copper. The phosphor bronze makes an excellent spring member; the copper gives increased conductivity. BRONCO 25/50/25 provides an electrical conductivity of 55% compared with solid copper.

BRONCO permits miniaturization. It permits you to make smaller units because you can reduce spring size without sacrificing conductivity.

No matter what your problem, it will pay you to consult with General Plate. Their vast experience in bonding any combination of malleable metals can overcome your problems . . . often reduce costs.

General Plate products include . . . precious metals clad to base metals, base metals clad to base metals, thin-gauge rolling, composite contacts, buttons and rivets, *Truflex*® thermostat metals, *Alcuplate*®, platinum fabrication and refining, #720 manganese age-hardenable alloy. Write for complete information and Catalog PR700 today.

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GENERAL PLATE DIVISION
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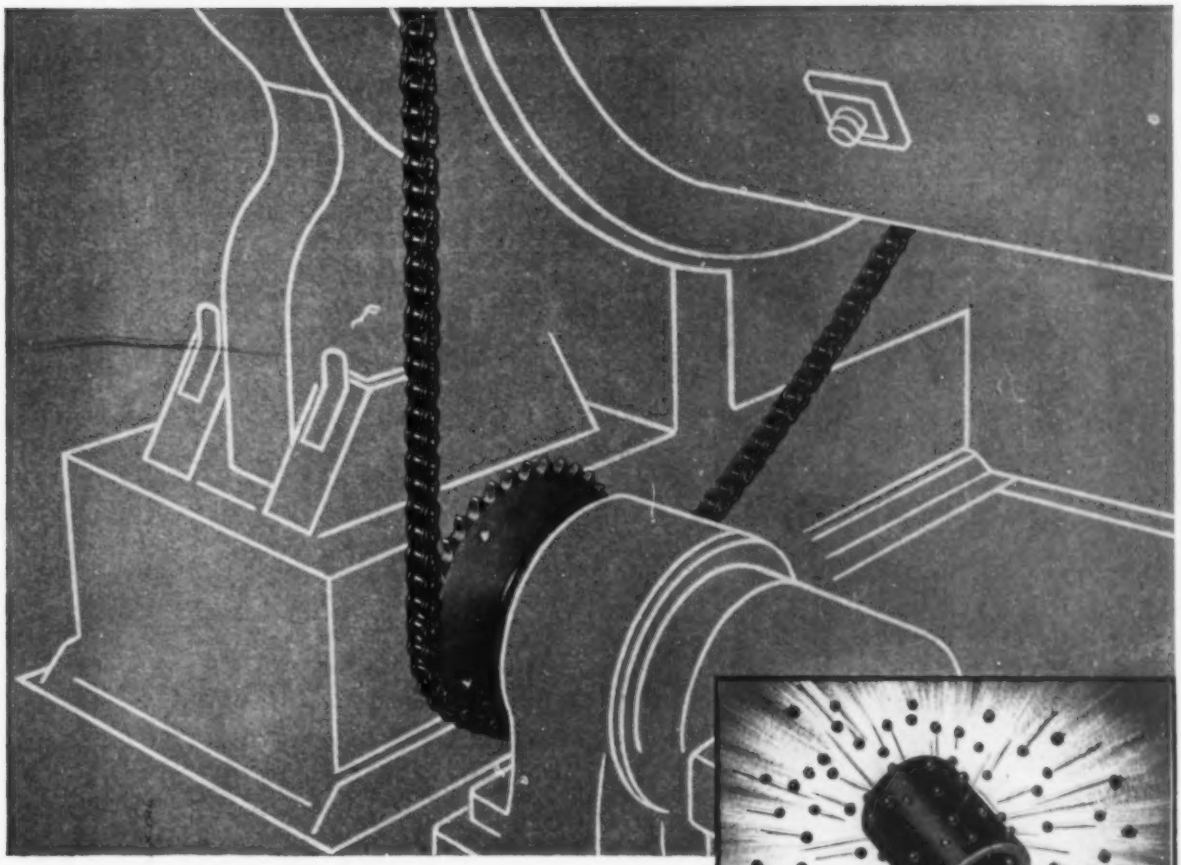
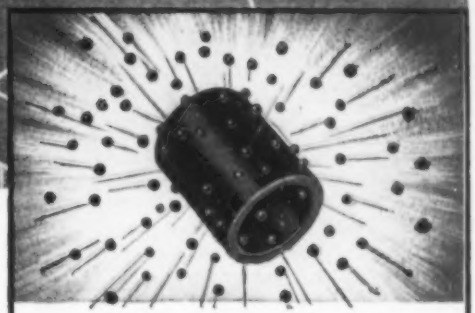
Yes, SHOT-PEENED rollers add fatigue life to your roller chain





Look for the distinguishing darkened rollers. Thousands of tiny steel balls hammer the metal—"cold work" each roller . . . pay off in extra fatigue life . . . added ability to withstand shock and impact.

. . . just one of the extra-life features you get with every LINK-BELT Roller Chain

WHETHER it's for drive or conveyor service, every Link-Belt Roller Chain gives you a performance bonus. In addition to shot-peened rollers, lock-type bushings multiply capacity to withstand shock loading. And closer heat-treat control, rigid testing and thorough inspection pay off in greater uniformity . . . extra years of life. Link-Belt Precision Steel Roller Chain is built in single or multiple widths, ⅜″ through 3″ pitch. Double pitch 1″ through 3″. A call to your nearby Link-Belt office will bring you prompt, expert service. Send for Engineering Data Book No. 2457.

12,110

LINK-BELT

ROLLER CHAIN & SPROCKETS

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities.

From the experience of building

NEARLY 8,000,000 *Maytag* WASHERS

get the mo$t for your Zinc Die Ca$ting Dollar!

In building nearly 8 million washers since 1907, The Maytag Company has always maintained dependability through top quality. The Maytag Master model of the wringer-type machine, first built in 1939, has always utilized ZINC Die Cast operating components and those in the current model typify the advantages of this metal and method of production.

ECONOMICAL, TROUBLE-FREE ASSEMBLY

Examine these six ZINC Die Castings from the standpoint of complexity of shape and you will realize why, by any other means of manufacture, a greater number of parts would be required to serve the same purpose. An absolute minimum of machining is required to prepare these castings for assembly and their dimensional accuracy assures perfect fit every time.

STRENGTH AND BEAUTY

The unusual castability of ZINC Alloy permits section thickness to be varied in proportion to the stresses imposed. Thus, these castings are thick only at vital points, to provide maximum strength with a minimum amount of metal. From an appearance standpoint, the smooth as-cast surfaces of the ZINC Die Castings are economically finished with a beautiful baked white enamel.

In selecting a die casting alloy there are many factors—both physical and mechanical—to be considered in addition to the base price of the metal. Ask any commercial die caster about the advantages of ZINC Die Castings —or write to us.

The New Jersey Zinc Company, 160 Front St., New York 38, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

No ONE chain serves every purpose

LINK-BELT offers the right chain

. . . engineered for your requirements

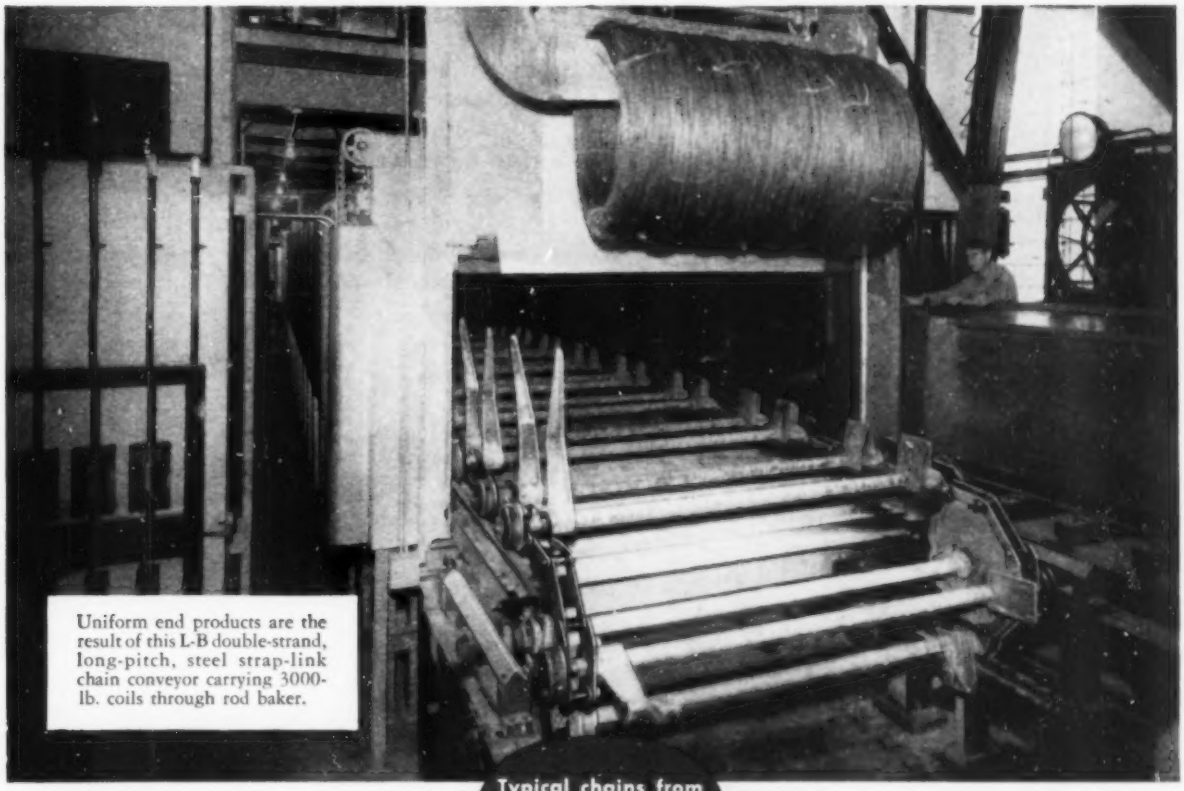
Don't settle for a "cure-all" chain to handle every job. Different types of chain have different characteristics. That's why Link-Belt makes a complete line of chains. Our engineers can recommend the correct type of chain to fit your particular needs . . . the one that does your job best.

Equally important is your assurance that *any* chain with the Link-Belt name will give you longer chain life. Accurate control of raw materials and processes . . . plus manufacturing refinements add up to the highest standards.

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa), Sydney (Australia). Offices, factory branch stores and distributors in principal cities. 12,781

LINK-BELT

CHAINS AND SPROCKETS



Uniform end products are the result of this L-B double-strand, long-pitch, steel strap-link chain conveyor carrying 3000-lb. coils through rod baker.

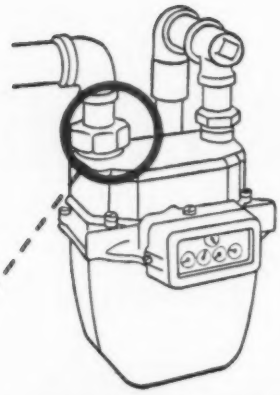
Typical chains from the complete LINK-BELT line

Class SS bushed roller chain with straight sidebars —for practically any conveying or elevating service.

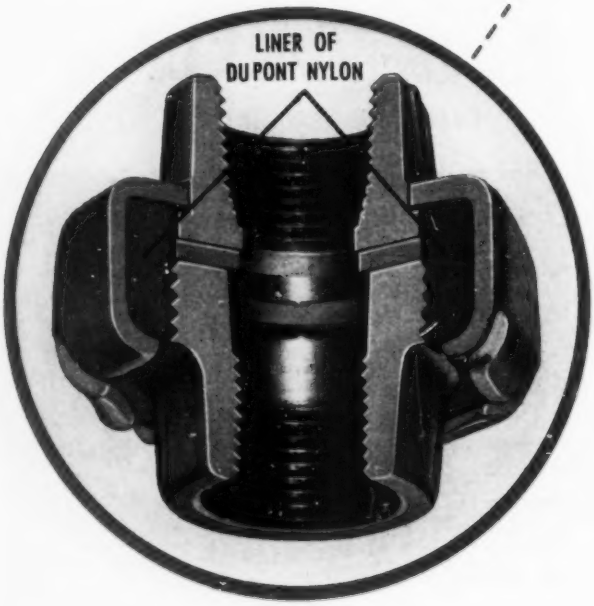
Class C combination chain — popular, durable, low cost design for elevators and conveyors.

Class SS bushed roller chain with offset sidebars —for heavy drive service at moderate speeds

Transfer chain with tilting dogs—for plate and slab travel, loads up to 300,000 pounds.



Du Pont Nylon plastic protects against corrosion



Liner molded for Universal Controls Corp., Dallas, Texas

Insulating liner lengthens life of gas and water pipe systems

A big problem affecting the life of underground gas or water pipes is electrolytic corrosion. It may be caused by contact between dissimilar metals or by stray electrical currents. Such corrosion can cut pipe life in half.

To solve the problem, Universal Controls Corporation designed a special nut to join the pipeline with the gas or water meter. It consists of an outer steel shell fitted with a threaded liner of Du Pont nylon plastic. The nut breaks the conductive circuit formed by the pipe and prevents the flow of current. Its success depends on a liner material that is non-conductive and provides a year-round, leakproof mechanical joint.

Du Pont nylon has the electrical properties to furnish the needed insulation. Its resiliency and strength give a good mechanical joint winter and summer. And nylon's toughness and abrasion resistance provide long, trouble-free service. In use, the nut increases pipe life . . . often doubles it.

This is another of the over 800 examples where Du Pont nylon is contributing economy plus improved performance in industrial parts. Du Pont nylon is unaffected by temperatures up to 250°F., requires little or no lubrication in many moving parts, resists chemical attack, absorbs shock. Perhaps it can help you improve or develop a product. For full information on nylon and other Du Pont plastics, write: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department, Room 103, Du Pont Bldg., Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY
Polychemicals
DEPARTMENT
PLASTICS • CHEMICALS

HERE'S PROOF

—It Pays to See the G.T.M. with your design problems!

IN designing its revolutionary new Gwaltney Spinning Frame, Saco-Lowell Shops turned to the G.T.M.—Goodyear Technical Man—for help in specification of V-belts to power the drive, and to maintain center distances between the pulleys.

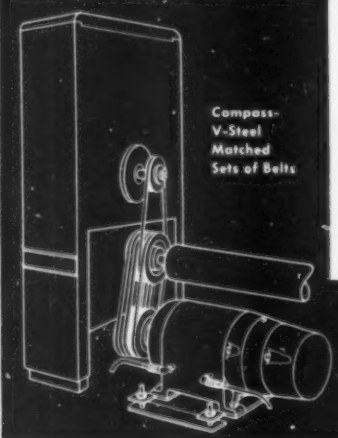
The G.T.M. recommended COMPASS-V-STEEL Belts—built around a strength member of airplane-type high tensile steel cables. These belts give the manufacturer a wide range of available speeds, negligible slippage, minimum stretch and long life.

The G.T.M. can help *you* in product design, too, wherever rubber in any of its forms can be used. You can reach him by writing Goodyear, Mechanical Goods Div., Akron 16, Ohio.

GOODYEAR
INDUSTRIAL RUBBER PRODUCTS

G.T.M.-Specified

COMPASS-V-STEEL Belts for Saco-Lowell Gwaltney Spinning Frames



Compass—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

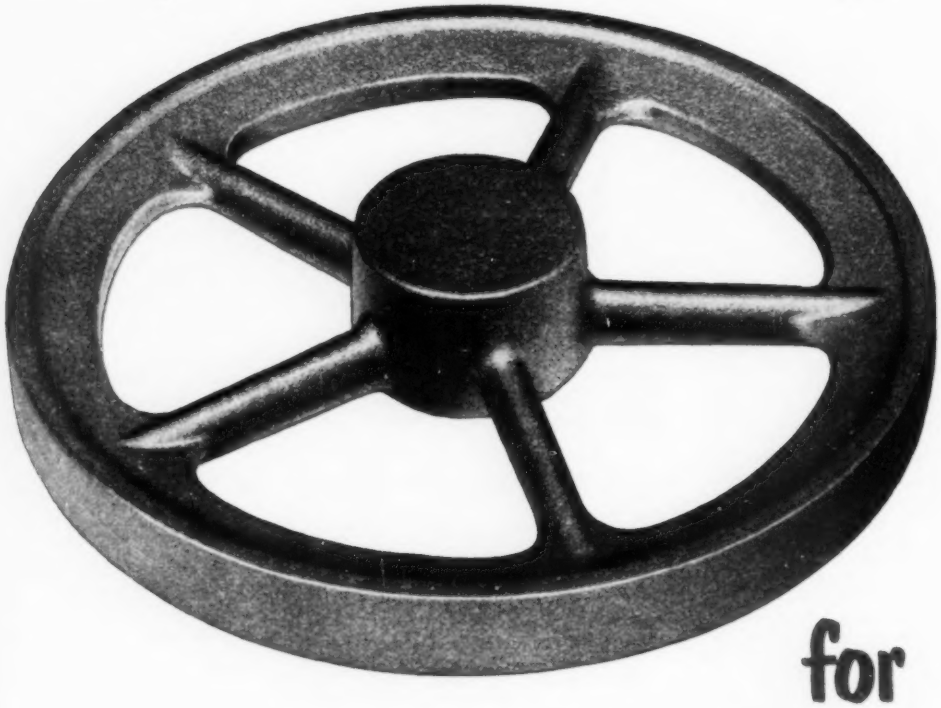
YOUR GOODYEAR DISTRIBUTOR *can quickly supply you with Hose, Flat Belts, V-Belts, Packing, Tank Lining, Rubber-Covered Rolls. Look for him in the yellow pages of your Telephone Directory under "Rubber Products" or "Rubber Goods."*

GOODYEAR

THE GREATEST NAME IN RUBBER

We think you'll like "THE GREATEST STORY EVER TOLD"—every Sunday—ABC Radio Network—THE GOODYEAR TELEVISION PLAYHOUSE—every other Sunday—NBC TV Network

Eaton Permanent Mold Gray Iron Castings—



for

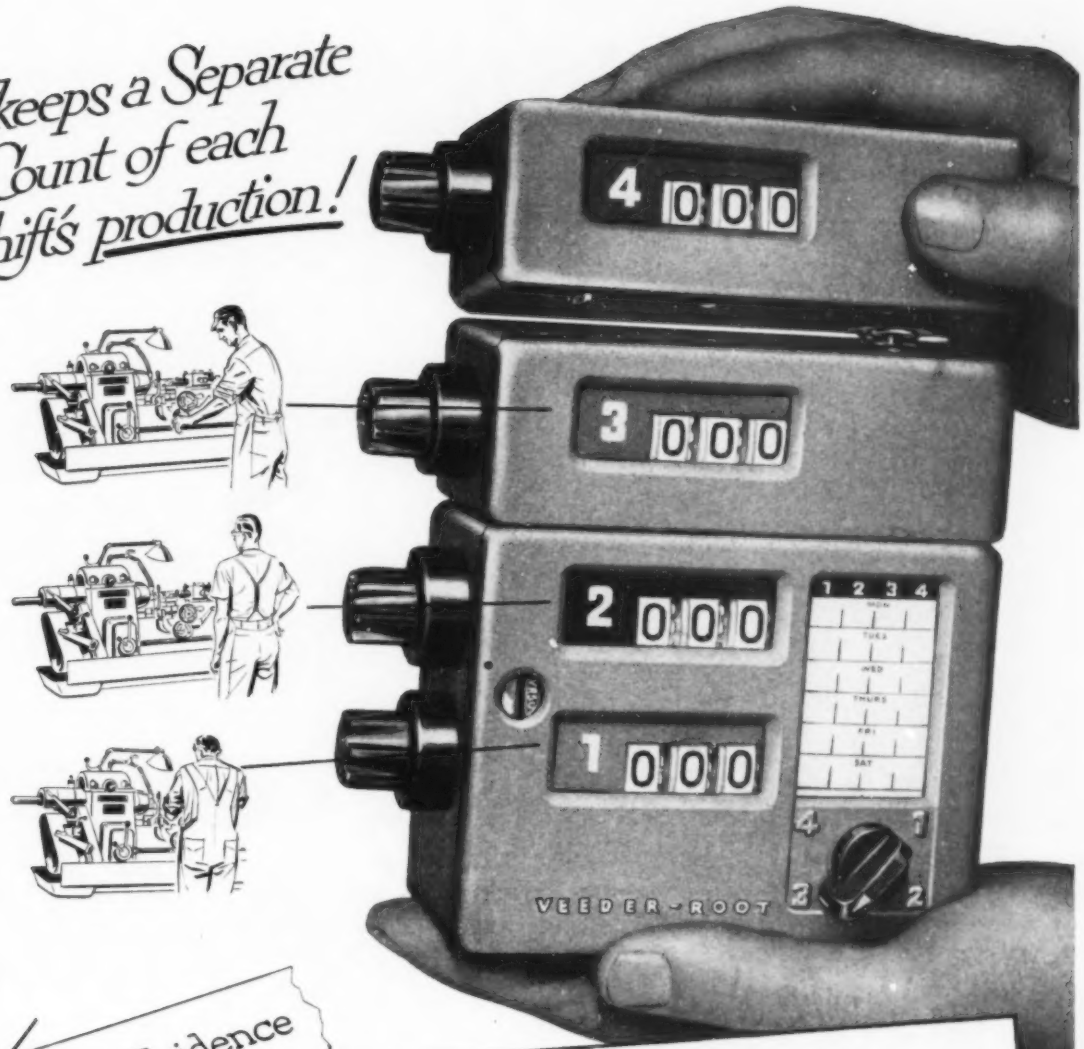
V-BELT PULLEYS

Send for your free copy of the 32-page illustrated booklet: "The Eaton Permanent Mold Foundry." It tells the story of Permanent Mold Castings and takes you on a picture-tour of the Eaton Foundry at Vassar, Michigan.

EATON MANUFACTURING COMPANY
General Offices: CLEVELAND, OHIO
FOUNDRY DIVISION: 9771 FRENCH ROAD • DETROIT 13, MICHIGAN

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

It keeps a Separate Count of each shift's production!



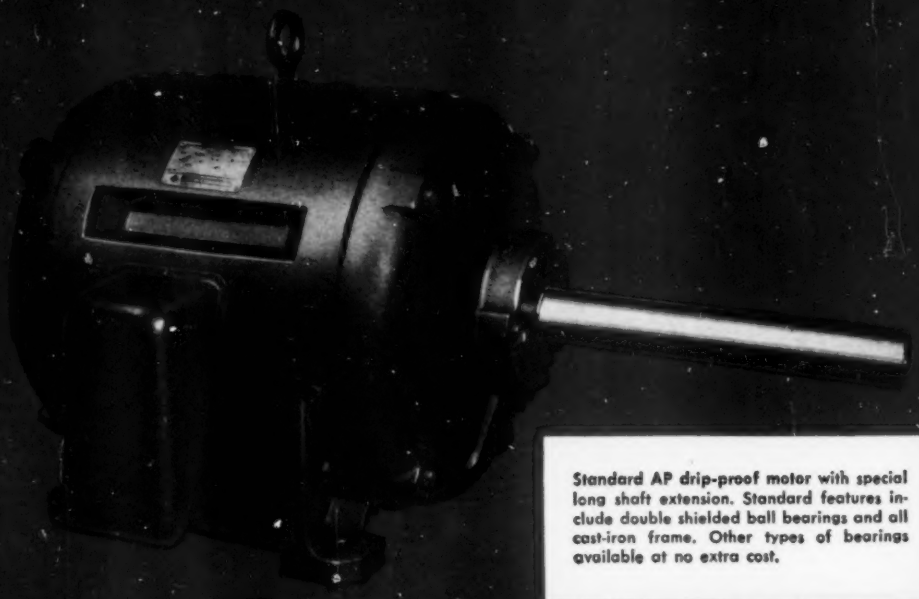
Added Evidence that

Everyone Can Count on VEEDER-ROOT

Here's a counter whose "count-ability" challenges your imagination. For this counter records, on a separate counting unit, the production of 1, 2, 3, or more shifts. The additional 4th unit can be used as a run or batch counter. These Veeder-Root 2-3-4 Convertible Shift Counters are applicable to a wide variety of production machines, to count in practically any unit desired . . . revs, strokes, pieces, or what do *you* want to count? *Write:*

VEEDER-ROOT INCORPORATED
"The Name That Counts"
HARTFORD 2, CONNECTICUT
New York 19, N. Y. • Chicago 6, Ill. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

Modified Standard Motor—



Standard AP drip-proof motor with special long shaft extension. Standard features include double shielded ball bearings and all cast-iron frame. Other types of bearings available at no extra cost.

ALLIS-CHALMERS MOTORS For Designers

Get Allis-

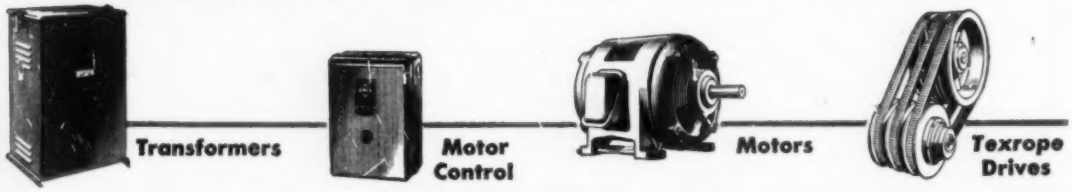
Send for Free Engineering Literature

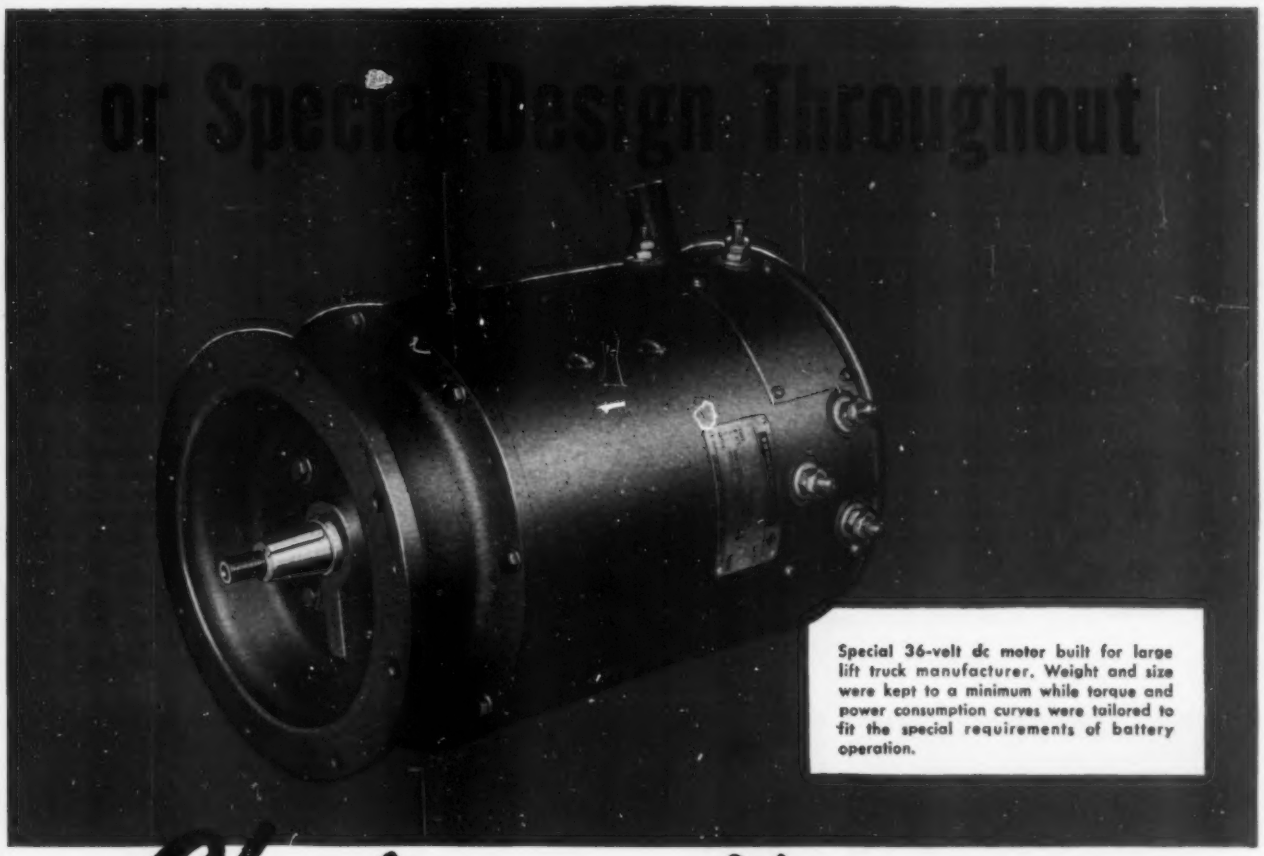
Motors
- ☐ Handy Guide to Motor Selection 51B6052
- ☐ Squirrel-Cage Motors *51B6210*

Control
- ☐ Across-the-line Starters 14B7132
- ☐ Reduced-voltage Starters 14B7215

Texrope Drives
- ☐ Handy Guide to *Texrope* Drives 20B6051
- ☐ *Vari-Pitch* Drive Engineering Data 20B7499

COMPLETE SERVICE *from power line to machine*





Special 36-volt dc motor built for large lift truck manufacturer. Weight and size were kept to a minimum while torque and power consumption curves were tailored to fit the special requirements of battery operation.

Chalmers Help ON YOUR SPECIAL MOTOR PROBLEMS

BRING YOUR SPECIAL MOTOR PROBLEMS TO ALLIS-CHALMERS. Whether your problem involves space restrictions, electrical characteristics, enclosures, performance curves or any other design feature, Allis-Chalmers engineers will help you. They know the problems of the design engineer intimately because Allis-Chalmers designs and manufactures control, drives and many types of machines in its own plants.

Modern Testing Facilities — You can be sure that an Allis-Chalmers special motor will deliver the performance designed into it. Every special design is tested in one of the most modern motor laboratories in the industry. Complete tests are run on both pilot and production units.

Nation-wide Service — Almost 100 Allis-Chalmers Certified Service Shops, located in every major industrial area in the country, are equipped to give prompt, factory approved service on any Allis-Chalmers motor you put on your equipment. In cases where special motors are used, the Certified Service Shop has access to factory data and uses only factory approved parts and procedures. You don't need to worry about service when you use an Allis-Chalmers special motor.

When your machines require special motors, call in the Allis-Chalmers representative early in the planning stage. He may be able to make valuable suggestions. Call your nearby Allis-Chalmers District Office or write Allis-Chalmers, Milwaukee 1, Wisconsin. A-3966

Texrope and Vari-Pitch are Allis-Chalmers trademarks.

ALLIS-CHALMERS

seven ways you save

WITH REYNOLDS FABRICATING FACILITIES

These photographs are representative of the tremendous Reynolds fabricating facilities . . . facilities that make possible seven basic economies to every manufacturer who uses Reynolds Aluminum Fabricating Service.

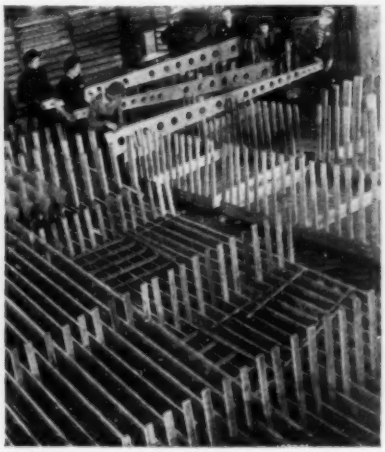
Not shown in these photographs, are two equally important advantages that Reynolds offers manufacturers. One, quality and production control from mine to finished product. Two, experienced design and engineering service.

You'll see *proof* of the latter advantages—along with proof of the seven basic economies pointed out in the photo captions—in each aluminum blank, roll formed shape, completed part or final assembly you get from Reynolds.

For your present needs or for development work on future models, contact your nearest Reynolds office listed under "Aluminum" in your classified telephone directory or write for your copy of the new "Complete Facilities" catalog to Reynolds Metals Company, Parts Division, 2051 South Ninth St., Louisville 1, Ky.

2 **Reynolds REDUCES YOUR RAW MATERIAL INVENTORY**

You get *pounds of parts* instead of pounds of metal when you use Reynolds Aluminum Fabricating Service. Like the automobile manufacturer who will receive the extruded aluminum window frames above, you can save, too, by cutting out that costly part of your metal inventory that does not go into finished parts. Over 30 Reynolds plants in 18 states are at your service!



3 **Reynolds RELEASES YOUR VALUABLE FLOOR SPACE**

Pictured above are just a few of 6,000 *different parts* for a single plane in production at Reynolds plants at one time during World War II. Imagine the floor space required for this production. Imagine the floor space *you* can save in *your plant*—space you can put to profitable use—when you call on Reynolds Aluminum Fabricating Service to turn out aluminum parts for your products.

4 **Reynolds ADDS TO YOUR CAPACITY WITHOUT INCREASING COSTS**

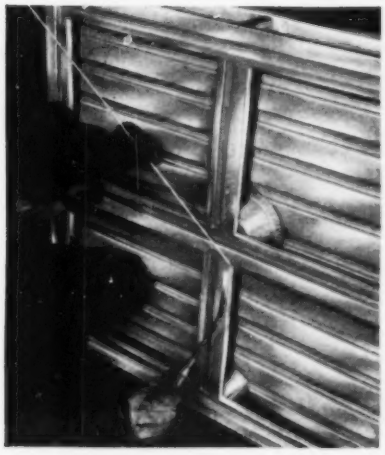
Here, in the photograph above, aluminum TV antenna is being formed on one of the seventeen Reynolds roll forming machines. The great variety of Reynolds specialized equipment enables you to obtain the economy of the machines best suited to your purpose, without making the tremendous capital investment in equipment and added plant capacity which would otherwise be required.

REYNOLDS ALUMINUM

BLANKING • EMBOSSING • STAMPING • DRAWING • RIVETING •

1 Reynolds CUTS YOUR SCRAP LOSS AND SCRAP HANDLING COSTS

The aluminum blanks on the conveyor at left are ready to go to a washing machine manufacturer. The scrap beside the press is remelted immediately right at the Reynolds plant. Thus Reynolds Aluminum Fabricating Service saves you—the manufacturer—an average of 30% scrap loss and also eliminates scrap handling expense on your part in sorting, storing and shipping.



5 Reynolds CUTS YOUR MATERIAL HANDLING COSTS

The aluminum pallets above will reduce material handling costs in many plants . . . and the manufacturer of these pallets is also reducing *his* material handling costs by getting *pounds of parts*, not pounds of metal, from Reynolds Aluminum Fabricating Service. Reynolds also takes the problems of scheduling, material supply, labor and machine availability off his—and your—hands!

6 Reynolds OFFERS YOU DELAYED MATERIAL BILLING

You receive 100% of your aluminum in finished parts when you use Reynolds Aluminum Fabricating Service. And, as these parts are generally billed after assembly into finished products, no investment is tied up in raw metal. These quality parts, like the shells of the aluminum cookers being buffed above, are available in a wide choice of finishes including color-anodized.

7 Reynolds ELIMINATES YOUR REJECT COSTS

Reynolds Aluminum Fabricating Service does away with your machine and labor production losses and inspection expense in rejects, because you pay only for finished, inspected parts. The conveyor line above, where refrigerator door trays are carefully inspected before packing and shipping, is just one of the many examples of Reynolds quality control from mine to finished product.

FABRICATING SERVICE

ROLL SHAPING • TUBE BENDING • WELDING • FINISHING

Here's a typical example of how the extra power capacity of Cog-Belts can solve design problems. Two diesel engines drive the pump on this sand and gravel dredge, and the former 16-belt drive handled a constant 140 horsepower load. When it was planned to step this up to 188 horsepower, 16 belts weren't enough. But adding more belts meant adding more grooves to the pulleys—and there was *no room* for large pulleys! The engineers were faced with redesigning the entire dredge, in order to make use of the engines' new output. Then 16 *Cog-Belts* were put on the drive. The same pulleys were used, but the Cog-Belts easily carried the 48 horsepower load increase. Instead of a complete redesign job on the dredge, it was a simple matter of changing from conventional V-Belts to Cog-Belts!

Want to save weight, space and cost on your V-Belt drive design?

This may be your answer . . . Cramped for drive space in your new design? If up to 25% shorter center distances will solve your problem, investigate the Dayton Cog-Belt.* It has no difficulty in operating on much shorter center distances than conventional V-Belts require.

If *weight* is your design problem, the Cog-Belt can lighten your design by as much as 28%. How? Because you can specify smaller pulleys . . . shorter belts . . . and, frequently, *fewer* belts.

Is *cost* the biggest headache in your design? Then be sure to see what the Cog-Belt offers the design engineer. In a great many instances, the greater horsepower rating of the Cog-Belt permits using *fewer belts, and pulleys with fewer belt grooves.* The savings possible in such cases are obvious. Even in drives which require the same number of belts, the pulleys for the Cog-Belts may be smaller (and thus cheaper) and the shorter center distances lend cost-cutting compactness to your design.

Send for design data!

Get the complete engineering story on how Dayton Cog-Belts save cost, weight, and space. Send for Dayton's 384-page design guide. And, of course, feel free to call on Dayton's engineering staff for help with your drives. No obligation — just write, wire, or phone.

*T.M.

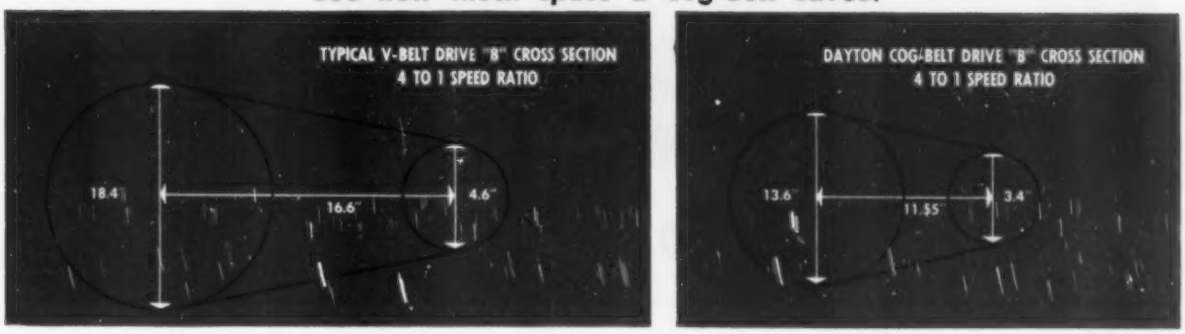
Dayton Rubber

Since 1905

WORLD'S LARGEST MANUFACTURER OF V-BELTS

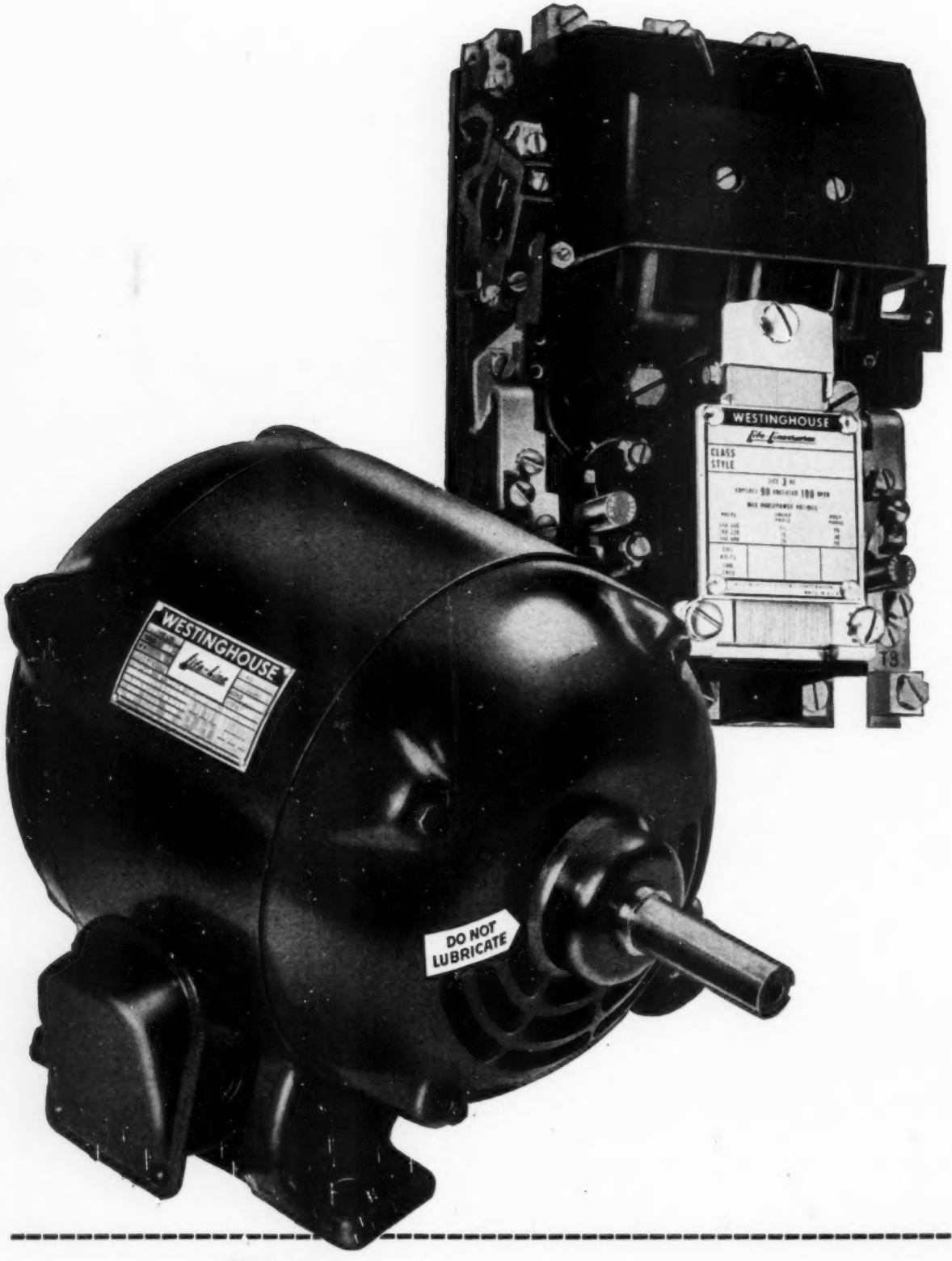
DAYTON 1, OHIO

See how much space a Cog-Belt saves!



© D. R. 1953

The Cog-Belt means a 30.6% saving in center distance . . . a 26% saving in height . . . a 47.2% saving in drive area!



WHAT *Life-Line* REALLY DELIVERS IS MORE SERVICE...LESS SERVICING

See the space you save with these modern *Life-Lines*

Both Life-Line motor and Life-Linestarter are space stretchers. The reason? Compactness. They are smaller, lighter than most conventional types . . . can be installed in close quarters where others can't be accommodated.

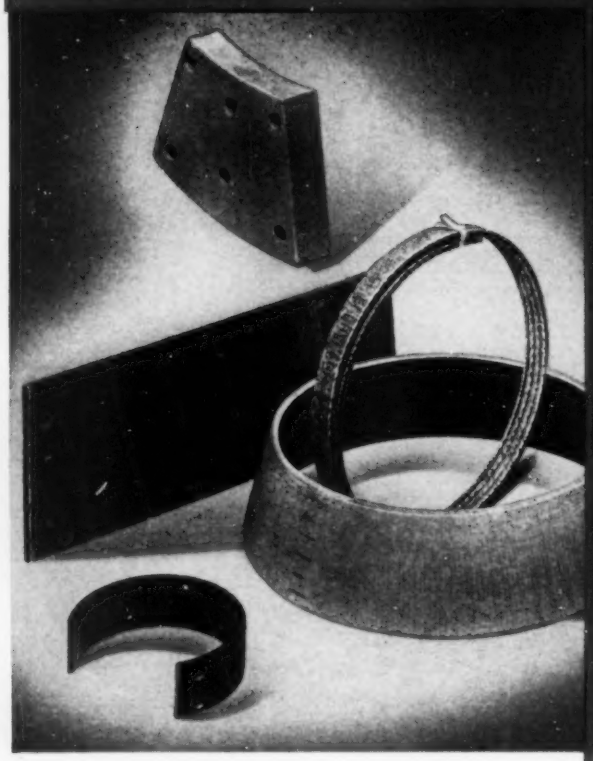
Notice that the motor has no grease cups or fittings. It's pre-lubricated . . . needs no further lubrication. This means you can cramp it into close quarters, forget greasing channels and nipples brought to outside of machine. Just install it in "hard-to-get-at" locations and forget it! The way to grease a modern motor is *don't.*

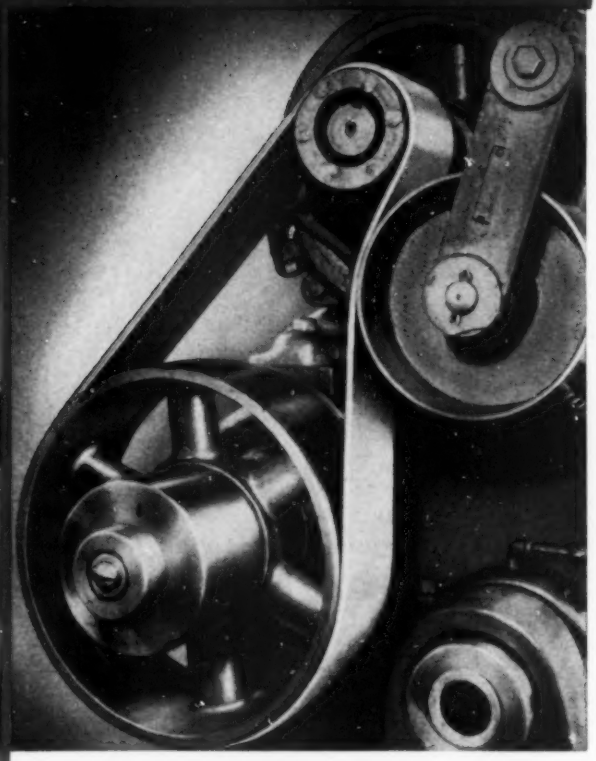
A check of the Life-Linestarter will show you all parts can be removed straight from the front. No need to allow extra work room for servicing. Further, wiring is straight through. You get simplified wiring, shorter leads. And you can have two electrical interlocks without increasing starter width. This means, smaller cavities and more compact cabinets.

These features give you the most advanced designed equipment available today. Built to match the modern advancements you build into your equipment. But get complete data. Ask your Westinghouse representative for latest information, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21692-A

YOU CAN BE SURE...IF IT'S Westinghouse

R/M Design people find Raybestos-Manhattan engineering service helpful on problems involving Asbestos, Rubber, Sintered Metal and Teflon* Products





Friction Materials

In the factory, on the farm, on the highway, even in the home . . . Raybestos-Manhattan friction materials contribute to the successful solutions of hundreds of "Stop and Go" problems. In the complete R/M line designers can find brake linings, brake blocks, clutch facings, bands, cones and many special shapes . . . precision-made of woven or molded asbestos or of various formulations of sintered metal. Each part is unique in design, size, composition, friction and engagement characteristics, and in suitability for a specific type of service. The parts illustrated above merely suggest the wide range of shapes and sizes available.

Mechanical Rubber Products

Raybestos-Manhattan has continually kept ahead of changing demands in the development of mechanical rubber products. The Condor Whipcord Endless Belt is an example of industrial foresight at R/M. This transmission belt has been known to outlast from 2 to 10 ordinary type endless belts on many drives. Made from strong de-stretched cords, endless wound and embedded in rubber, it is a highly flexible belt, unaffected by temperature changes. The exclusive Manhattan Extensible-Tip prevents cover splice separation by extending the joint stress over a wide area. The same R/M ingenuity in engineering applies to hose, conveyor and V-belts, molded rubber products.

Brake Blocks, Linings and Clutch Facings

Fan Belts and Radiator Hose

Mechanical Packing and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Rubber Lined and Covered Equipment

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL

To better serve you PROMPTLY.. So that R/M sales, research, engineering and production can best coordinate to handle your problems . . . and so that we can serve you with least delay . . . please wire, phone or write the division listed under the product in which you are interested.

Packings, Gaskets,
Asbestos Textiles and Teflon* Products

Here are a few of the hundreds of different R/M packings and gasket sheets. Raybestos-Manhattan makes available to design engineers a complete line of packings made of rubber, duck and rubber, flexible metal, plastic, asbestos, ramie, flax and other fibers to seal against air, water, steam, gas, oil, solvents, foods, hydraulic fluids, etc. R/M also manufactures asbestos textiles, woven yarns and cloth. And R/M meets specifications for Teflon packings, rods, sheets, tubes, tapes and fabricated parts.

**Du Pont trade-mark for its tetrafluoroethylene resin*

Rubber Covered Rolls

Sintered Metal Friction Elements

Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

AND TEFLON PRODUCTS

MECHANICAL RUBBER PRODUCTS

Manhattan Rubber Division
Raybestos-Manhattan, Inc.
Passaic, N.J.
Gregory 3-2000

PACKINGS, GASKETS, ASBESTOS TEXTILES AND TEFLON PRODUCTS

Packing Division or
Asbestos Textile Division
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211

FRICTION MATERIALS

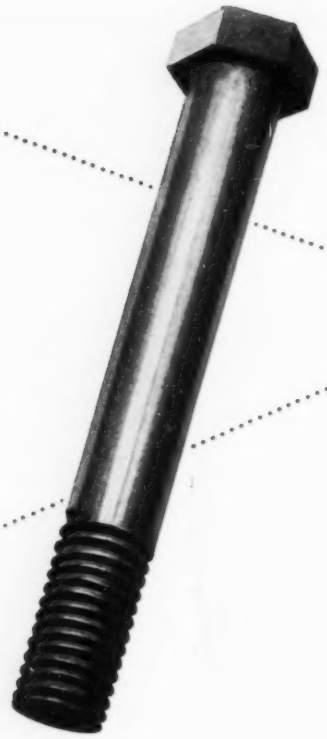
Equipment Sales Division
Raybestos-Manhattan, Inc.
445 Lake Shore Drive
Chicago 11, Ill.
Superior 7-5126

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Neenah, Wis. • Manheim, Pa. • Bridgeport, Conn. • No. Charleston, S.C. • Crawfordsville, Ind. • Peterborough, Ontario, Canada

Manufacturers of Mechanical Rubber Products • Packings • Brake Linings • Brake Blocks • Clutch Facings • Sintered Metal Products Fan Belts • Radiator Hose • Rubber Covered Equipment • Asbestos Textiles • Teflon Products • Abrasive and Diamond Wheels • Bowling Balls

You wouldn't
hold a bolt
to ± 0.0002 in.



Why pay for unneeded precision in ball bearings?

In many applications where speeds and loads are moderate, you don't need a precision bearing. When this is the case, Schatz "Commercial" Ball Bearings can cut your costs by as much as 85%—*without any sacrifice in operating efficiency.*

Why are savings like this possible? Because "Commercial" Ball Bearings are designed to wider tolerances than precision bearings...because they are available unground, partially-ground, or fully-ground. And, because, in almost all cases, cages are not used.

If you have an application where speeds and loads are moderate, it will pay you to look into Schatz "Commercial" Ball Bearings. To learn how you may save, write for literature described below.

THE SCHATZ MANUFACTURING COMPANY
6758 Fairview Avenue, Poughkeepsie, New York

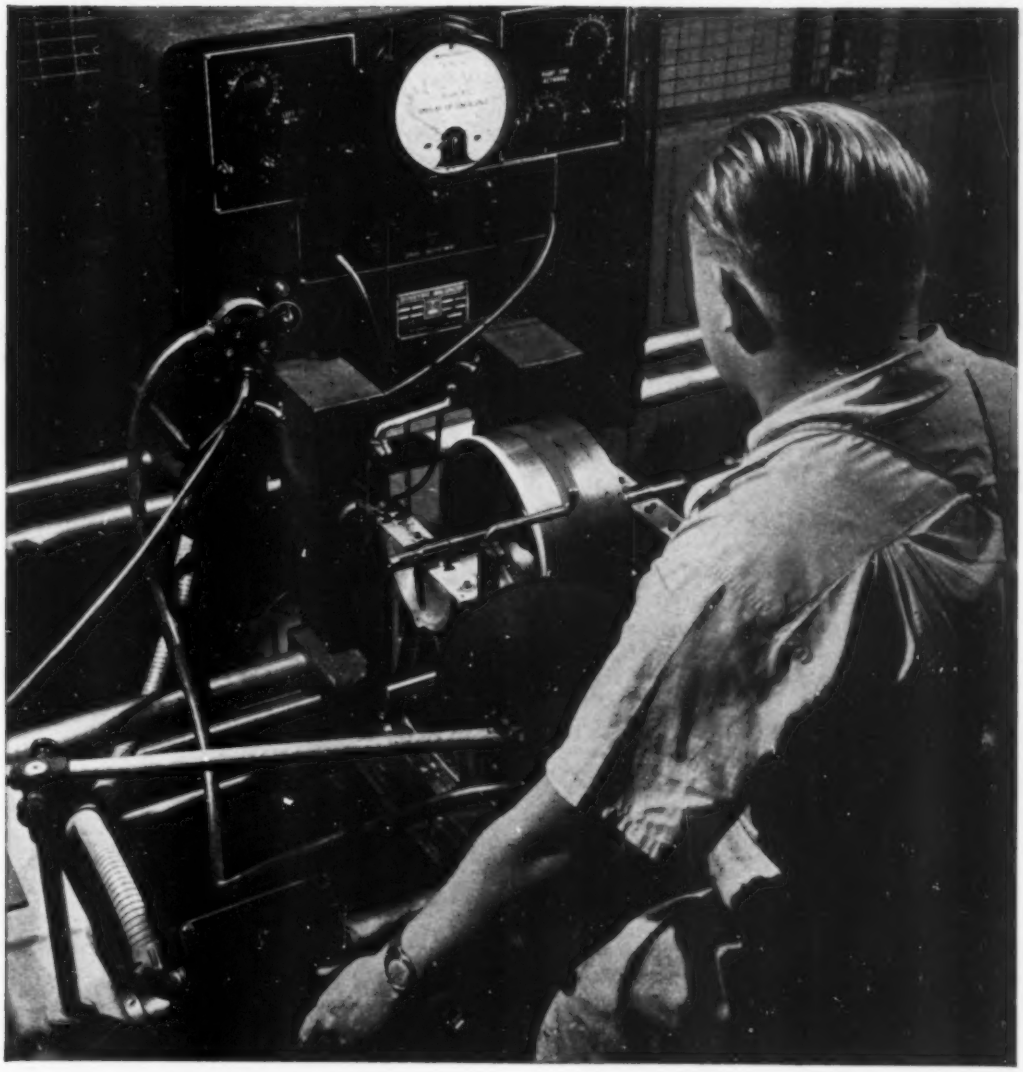
Schatz "Commercial" Bearings used on these products

Dishwashers • Outboard motors
Automobile steering mechanisms
Elevators • Box machinery
Office equipment
Flexible shafts • Lawn mowers
Masonry cutting equipment
Textile machinery • Farm equipment
Laundry equipment
What about your product?

The oldest, largest manufacturer of "Commercial" ball bearings

SCHATZ "Commercial" BALL BEARINGS

Technical literature available:
Schatz Catalog 11 contains drawings and specifications of Schatz Ball Bearings.
Technical Bulletin tells how to determine proper type and size "Commercial" Ball Bearing for various speeds and loads.
Nylon Bearing Parts discusses advantages of nylon parts in "Commercial" bearings.



Sure Cure for the Shakes

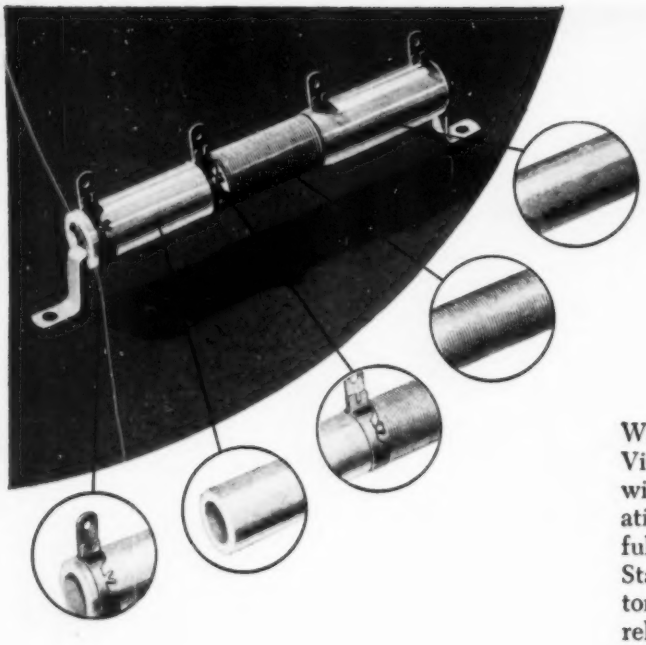
LET VIBRATION creep in and even the best of production equipment fails to perform; for, like oil and water, vibration and precision just don't mix. Federal controls vibration at the source with periodic inspection and balancing of all rotating parts. The pulley shown above, for example, is being balanced in a Gisholt Dynetric Balancer; the slightest sign of imbalance draws an automatic signal. By such minute attention to detail Federal maintains precision on the production line—one reason why you can be sure of friction-free performance with Federal bearings.

The Federal Bearings Co., Inc., Poughkeepsie, N. Y.

Federal

Ball Bearings

One of America's Leading Ball Bearing Manufacturers



VITROHM

are your

Ward Leonard manufactures its own ceramic cores, Vitrohm enamel and terminals. Even the resistance wire is drawn to our own specifications. Every operation required to build a Vitrohm resistor is carefully and constantly checked and controlled by our Standards Department. That's why Vitrohm resistors assure you complete uniformity, accuracy and reliability, even under the most adverse service conditions.

Ward Leonard has the largest selection of stock

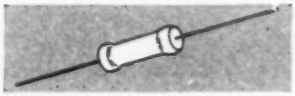
7 stock resistors

Vitrohm stock resistors range from 5 to 200 watts with resistance values from 1 to 250,000 ohms. Made-to-order Vitrohm's are available from 5 to 550 watts with values from 0.04 to 1,750,000 ohms.

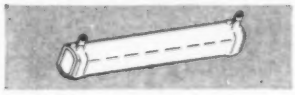
FIXED VITROHM
Used for voltage dropping and current limiting.

ADJUSTOHM
Gives circuit adjustability for voltage dividing or regulating purposes.

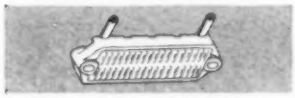
STRIPOHM
For compact aviation, communication and navigation equipment.



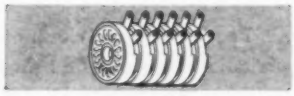
AXIOHM
Used in electronic equipment requiring miniature power resistors.



NON-INDUCTIVE
For low inductance and distributed capacitance in high frequency circuits.



PLAQOHM
Used in compact, high frequency electronic equipment.



DISCOHM
A miniature resistor for low inductance values and distributed capacitance.

WARD LEONARD

WARD LEONARD ELECTRIC COMPANY

MOUNT VERNON, NEW YORK

Result-Engineered Controls Since 1892

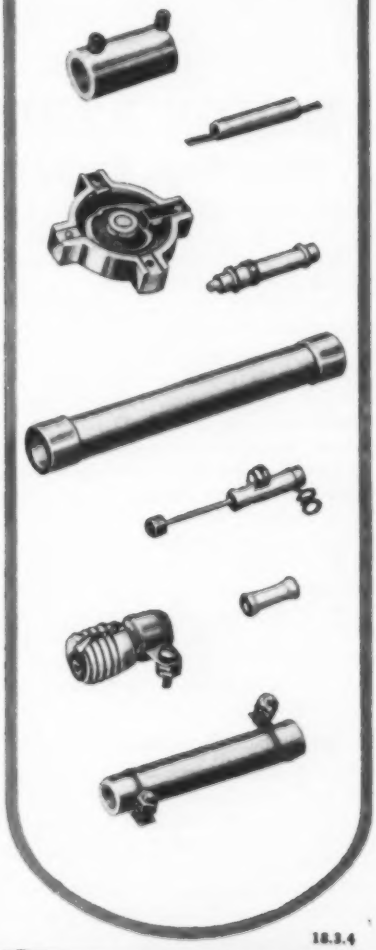
RESISTORS

best buy

resistor types and sizes ever offered by any manufacturer. Also available to meet customer's exact specification is a complete stock of components ready for immediate assembly into made-to-order resistors. Our controlled component manufacture and inspection, plus a wider selection of types, make Ward Leonard your best buy in resistors.

For full information on Vitrohm resistors, write for Catalog No. 15 to Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y.

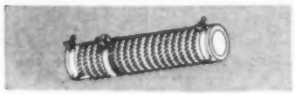
Special form resistors to meet unusual requirements



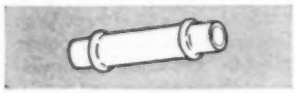
18.3.4

11 made-to-order resistors

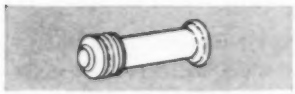
(these plus all the stock resistor types)



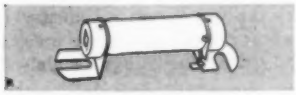
RIBFLEX
Used in circuits where high wattage must be dissipated in small space.



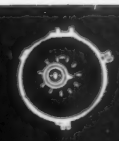
FERRULE TERMINAL
For rapid interchangeability of resistance values or resistor replacement.



SCREW BASE
With an Edison screw base for mounting to provide rapid means of changing resistance.



BRACKET TERMINAL
Has leads silver brazed to brackets for easy interchange or renewal of unit.

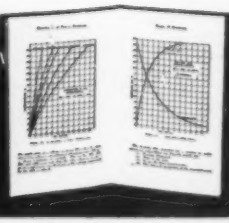


RHEOSTATS

RELAYS

MOTOR CONTROLS

CHROMASTER

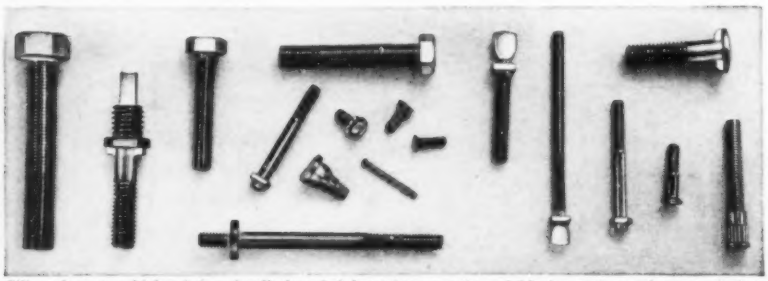


Ward Leonard's complete engineering textbook, "Handbook of Power Resistors," $3. per copy.

BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport Brass Co. MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND. — IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



Silicon bronze cold headed and roll threaded fastenings are dependable in service and economical to fabricate — courtesy Scovill Mfg. Co., Waterville, Conn.

SILICON BRONZE FASTENINGS
Meet High Engineering Requirements

Vital equipment and, in fact, life itself may depend upon the reliability of metal fastenings used. Consequently, it is absolutely necessary from an engineering standpoint that the metal, from which fastenings are made, be reliable and dependable under the various service conditions encountered such as high stresses, corrosive environments of various kinds, moisture, fatigue, temperature changes, etc.

For all-around general engineering requirements for making cold headed items, Silicon Bronze 609 wire is widely used. It contains about 98% copper and 2% silicon and has the fine corrosion resistance and the workability of copper plus the strength and toughness of some grades of steel. Since they are not whittled away by rust, silicon bronze articles retain their original physical properties.

Resists Stress Corrosion Cracking

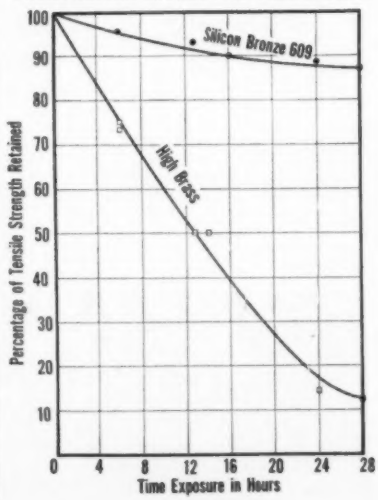
Silicon bronze is much more stable than the yellow brasses as far as resistance to stress corrosion or season cracking is concerned because of its very high copper content.

The chart shows the comparative behavior of accelerated stress corrosion tests on Silicon Bronze 609 versus yellow brass. The samples, while under tension, were immersed in concentrated ammonium hydroxide vapors. Tested after a 24-hour period, the silicon bronze had retained 87% of its tensile strength. Any loss was due to the reduction in cross-sectional area from the corrosive action of the solution. On the other hand, the yellow brass had cracked badly and only 12% of its original tensile strength remained.

This laboratory test is, of course, much more severe than encountered in actual service. It indicates that Silicon Bronze 609 is suitable for outdoor service conditions but yellow brass, under stressed conditions in the same environment, is not recommended.

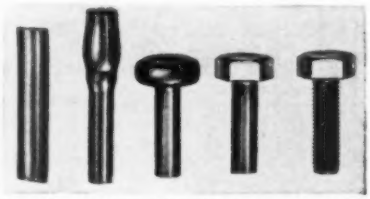
Although Silicon Bronze 609 is moderately strong in the annealed condition (about 43,000 psi), it attains a very high tensile strength when hard drawn to the temper suitable for making screw products by cold forging and roll threading. The hard drawn wire is extremely malleable and is excellent for making cold headed products even with very large heads. No relief anneal is necessary for the finished products because the metal does not become brittle even after a high degree of cold working.

STRESS CORROSION TESTS — COMPARISON BETWEEN SILICON BRONZE AND YELLOW BRASS



Making a Cap Screw with an Oversized Head

The first operation reduced the .340" wire to .276" by "extrusion." This cold working operation not only increased the strength of the shank but pushed up extra stock required in order to fill the die for the large head. Extrusion and thread rolling increased the tensile strength of the shank to about 100,000 psi as compared with an ordinary low carbon steel screw which averages about 70,000 psi.



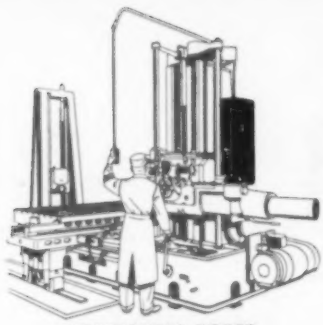
Steps for making a silicon bronze cap screw with an unusually large head — Scovill Mfg. Co.

The cold heading and roll threading processes have many advantages both from quality and economy standpoints — great strength, uniformly high quality, close tolerances, high speed manufacture, and very low scrap generation during fabrication.

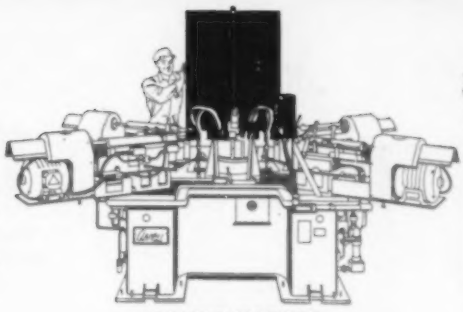
Many Applications

Silicon bronze fasteners and special cold headed parts, as illustrated above, can be used to advantage for practically every product in every industry. Examples are: common bolts and nuts; clamps and special fastenings for high-tension and standard voltage electrical transmission equipment; builders', marine and pole line hardware; home appliances, outdoor signs, transit systems, automotive accessories, valve stems, instruments, water meters, signal systems, mine equipment, etc., etc.

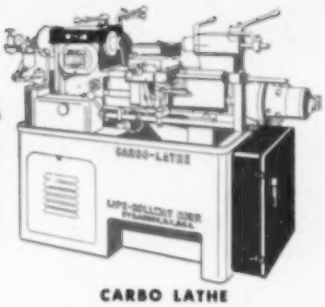
More detailed information on wire alloys for cold heading is given in the Bridgeport Brass "Technical Handbook." Please contact Bridgeport's nearest sales office for laboratory help and your metal requirements. (9648)



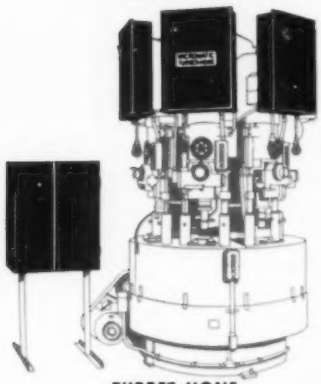
HORIZONTAL BORER



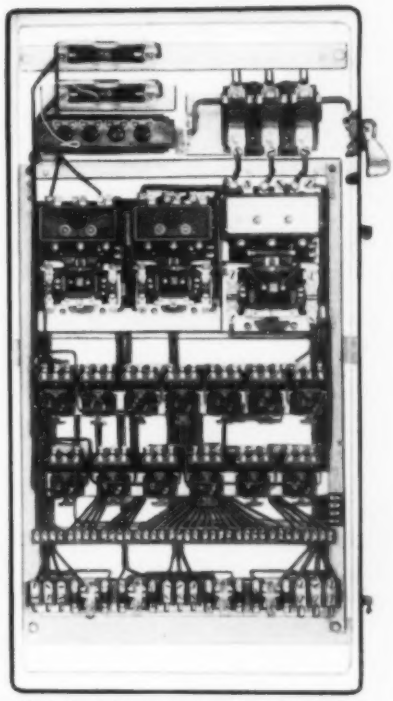
DRILLING MACHINE



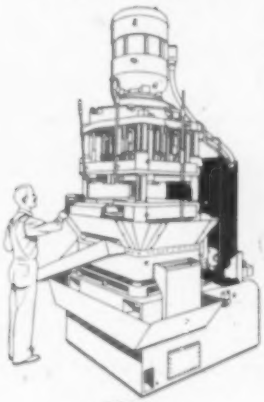
CARBO LATHE



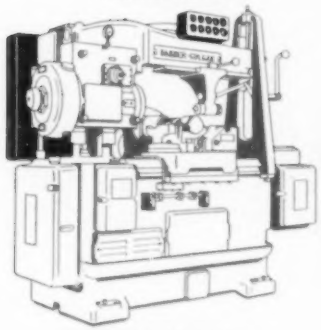
TURRET-HONE



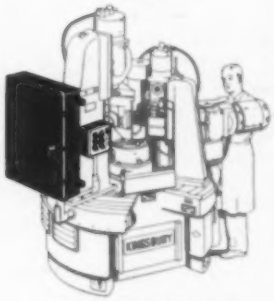
Typical machine tool control panel showing disconnect unit, contactors, and accessories



DRILL



HOBBING MACHINE



TAPPING MACHINE

MACHINE TOOL CONTROL PANELS

● ● ● ENGINEERED TO SATISFY YOUR NEEDS

Allen-Bradley control panels are popular with machine tool builders, because—

1—A-B contactors and relays have acquired a world-wide reputation for dependability and precision control. Consistently, they perform millions of trouble free switching operations.

2—A-B engineers, through long experience, are skilled in developing sequence control panels. Due to the compact design of A-B components, smaller panels are a common result . . . which means less space is used on the machines.

3—The A-B trademark is a sales asset for your motorized machine tools. It is the mark of Quality in motor control . . . known and accepted by machinery buyers, everywhere.

It will pay you to discuss your control problems with Allen-Bradley. A field force of Allen-Bradley engineers, located in all principal cities, is at your service. We shall be glad to send you the A-B Handy Catalog.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.

4-53-R

A-B Quality

ALLEN-BRADLEY QUALITY

SPECIAL PANELS

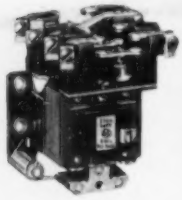
A-C & D-C TROUBLE FREE RELAYS

from 1 to 12 POLES

THE UTMOST IN RELAY DEPENDABILITY

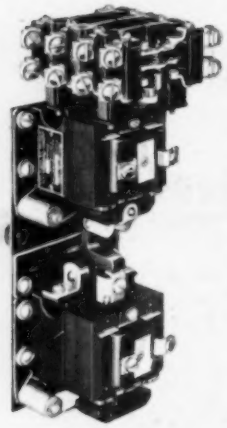
HUM-FREE A-C RELAYS

Relays in hospitals, churches, etc., must be hum-free. For these places, Types BM and BXL relays are recommended. Continuous coil currents are not needed to hold them closed. Also useful for machine tools.



TYPE BM—Residual Magnetic Latch

Contacts are held closed by residual magnetism of core. A demagnetizing coil current opens relay.



TYPE BXL—Mechanical Latch 2-Unit Relay

Lower solenoid trips the mechanical latch of the upper relay to open the upper relay contacts.

Bulletin 700 Relays are built to the same critical operating standards as the larger switching units in the Allen-Bradley line.

They have only one moving part . . . the simple solenoid plunger that opens and closes the double break, silver alloy contacts. Available in many varieties of contact arrangements . . . up to 12 poles . . . with or without enclosures. Long, trouble free life makes these relays the ideal pilot controls for installations which are likely to get infrequent inspection and maintenance.

Send for Bulletin 700 containing complete details on ratings, dimensions and related accessories.

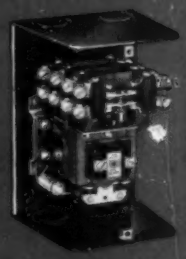
Allen-Bradley Co.
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY

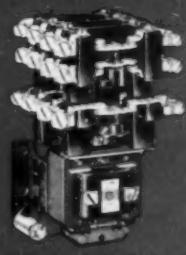
RELAYS & CONTACTORS

A-B Quality

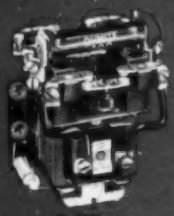
TYPICAL RELAYS in the ALLEN-BRADLEY LINE



Relay in Enclosure



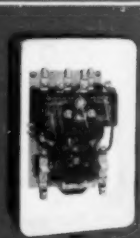
8 Pole A-C Relay



3-Wire Thermostat Relay

Low Current A-C Relay

D-C Relay



Bulletin 709 Size 3 Solenoid Contactor

4-53-R

SPEED PRODUCTION, CUT COSTS ON LARGER PARTS

You'll want this new report on recent developments in mass-producing giant components

You may already have turned to plastics to solve some of your design and production problems for small parts. But today, with larger and larger plastic moldings possible, you may be asking this question:

"Can I realize the same considerable production advantages on *large* components that I'm now enjoying with small plastic moldings?"

To answer your question authoritatively, Monsanto has issued a report that tells how product designers can now consider new giant plastics applications that were out of the question a few short years ago—because of huge new molding machines, improved plastics formulations, and the continuing progress in plastics molding technology.

We think you'll be interested in this new study, which shows *how* leading manufacturers are already using plastics to simplify production and cut costs on ever-larger component parts. For your free copy, please mail the handy coupon.

CHICAGO MOLDED PRODUCTS CORP.

FREE—REPORT TO DESIGN ENGINEERS

Monsanto's latest study, on how "one-shot" plastic moldings of giant parts can simplify production, cut costs.

MONSANTO CHEMICAL COMPANY, Plastics Division, Room 2127, Springfield 2, Mass.

Please send me your report on how plastics simplify production of large units.

Name & Title _____

Company _____

Address _____

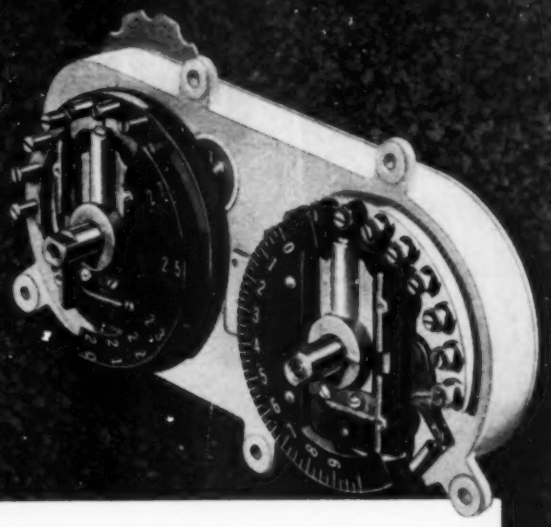
City, Zone, State _____

MONSANTO
CHEMICALS AND PLASTICS

SERVING INDUSTRY...WHICH SERVES MANKIND

DIE CASTING—

the fastest and most economical route from raw material to finished product



CASE HISTORIES FROM MT. VERNON FILES

Fast production with *economy*—that's die casting's supremely important contribution to the needs of today. For die casting is industry's versatile top-speed, money-saving production tool.

Take, for example, the Lewyt Corporation. Even as vacuum cleaners march steadily along its production lines, a division of the plant is being devoted to manufacture of components for military radio transmitter-receiver sets.

Shown here, is a Lewyt-made, panel-mounted dial drive assembly. The gear train housing, produced by Mount Vernon, is cast in two matching halves, *complete with bushings and all details as specified.* With a minimum of machining, a tight fit of the two portions is obtained, and the housing is ready to receive the intricate gear assembly needed for coupling the megacycle and one-tenth megacycle controls, and other parts, to each other

However complex or simple *your* product, and however critical the dimensional accuracy it demands, it is very probable you can produce it most profitably by Mount Vernon die casting. So send us your specifications. Our wealth of specialized knowledge is at your disposal, and we'll gladly make recommendations based on your particular needs.

MT. VERNON
DIE CASTING CORP.
MT VERNON, NEW YORK

WORM GEARING—universal in its application—affords advantages for almost every power transmission job. Whether you want worm gearing sets or speed reducer units, you will find drives to meet your need in the complete Cleveland line.

Vickers Inc. hydraulic winch in operation on a Piasecki Hup-1 helicopter. Inset at left shows built-in Cleveland worm gearing.

Small Cleveland gearing speeds sea rescue

CLEVELAND worm gearing now has a part in a new kind of sea rescue. Just after the war, for the first time, a Vickers hydraulically-operated winch mounted on a helicopter hoisted two men to safety when an oil barge ran aground. Now use of the winch is standard practice, replacing hard-to-climb rope ladders previously used.

Vickers Inc. chose Cleveland worm gearing to drive the winch because it is small enough and light enough to satisfy rigid weight and bulk restrictions and is capable of governing efficiently sudden stops and starts and changes of direction involved in rescue work. To date Cleveland worm gearing has participated in over 1700 Korean missions.

Cleveland manufactures worm gearing and worm gear speed reducers in a wide range of types and sizes, large and small, to meet the requirements of any machinery builder or user. Write today for Catalog 400. The Cleveland Worm and Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

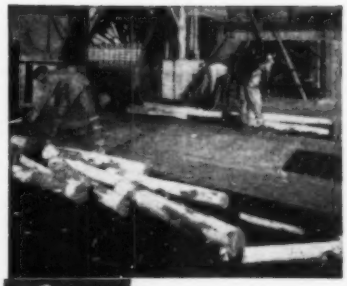
Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers, Limited.

Is there ONE chain your drive or

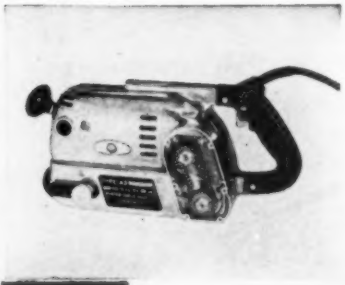
YES! And you'll find the answer in LINK-BELT's complete chain line — a size and type for your specific job

BABY CREAM JARS are capped and inspected as they ride on individual carrier plates of Link-Belt Universal Crescent flat-top chain conveyor. Vertical curves as well as sharp horizontal bends are easily traversed. Link-Belt makes six different types of flat-top chain, each engineered for a specific service.

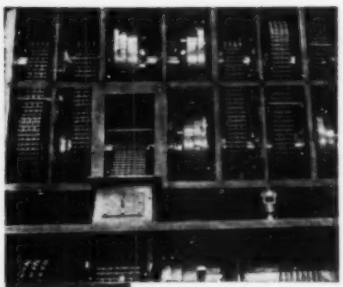
that best meets conveyor problem?



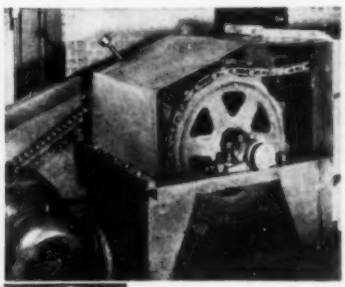
PULPWOOD LOGS are discharged from drum barkers onto a 12-strand Link-Belt sorting table. This Class C Promal chain resists both abrasion and corrosion, provides long life under tough conditions.



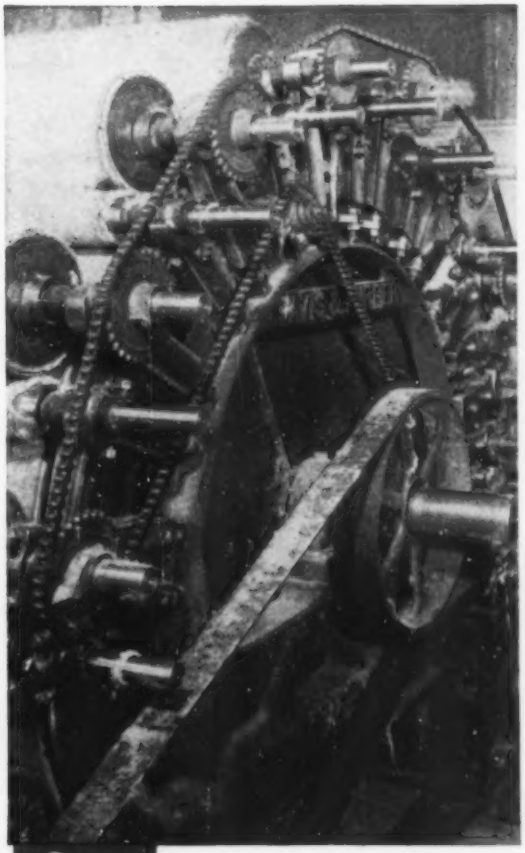
PORTABLE BELT SANDER employs high speed, compact, efficient Link-Belt 5/16-in. pitch Silverstreak Silent Chain. Designers throughout industry rely on this drive for pinion speeds up to 9000 rpm.



OIL FIELD DRILLING RIG utilizes multiple-width Link-Belt Roller Chains with their E-Z Assembly feature. Even under the most rugged service conditions, these dependable chains provide long life.



COAL is handled by Link-Belt rivetless-chain flight conveyor that includes Flint-Rim Sprockets. Link-Belt makes all sizes and types of cut and cast tooth sprockets for every drive and conveyor service.



WOOL CARDING MACHINE ROLLS are driven by Link-Belt Precision Steel Roller Chain and Sprockets to insure positive, uniform transmission of power independent of temperature variations.

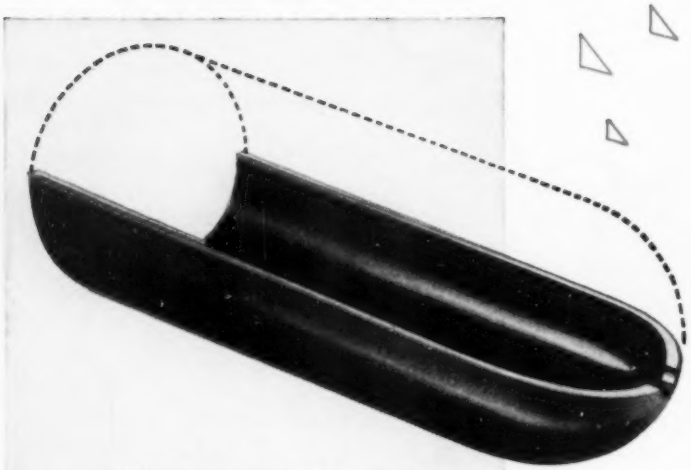
Follow the lead of all industry — for your complete drive and conveying chain needs rely on . . .

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices in Principal Cities. 13,097

How Tubular Parts with Formed Ends Can be Produced most **ECONOMICALLY**



Here is a typical case of economy. Shown is a section of a cylindrical part now made in one piece from Wolverine tube with both ends almost closed by means of the Wolverine Spun End Process.

Having no seams or joints, this redesigned part offers assurance against leaks; and makes the complete unit more dependable at all times.

This product was formerly made from a cylindrical form capped at both ends and silver soldered at the joints.

*A PATENTED PROCESS RE. 22465.

Tubular parts requiring tapered, rounded, flat or other shaped ends can be made easily, quickly and economically by the Wolverine Spun End Process*.

By virtue of their improved design, the finished parts made by this process perform more efficiently, and their modern lines add to the sales appeal.

This streamlined design also has the advantage of eliminating several parts, thereby reducing labor and material costs and assembly time as well.

A request on your letterhead will bring you a copy of our brochure "Spun End Process."

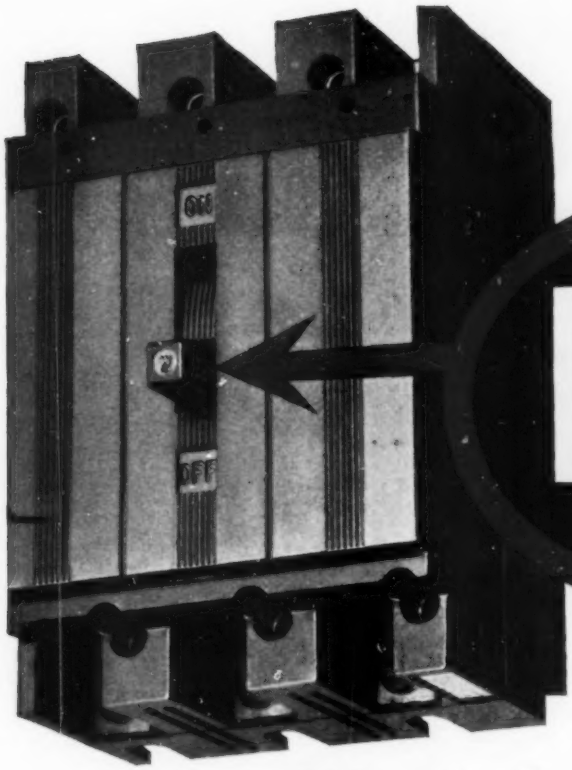
Other Wolverine Products

CAPILATOR*
—the capillary tube for restriction purposes
COMMERCIAL TUBE
AUTOMOTIVE TUBE
CONDENSER TUBE
COPPER WATER TUBE (K-L-M)
ELECTRIC WELDED STEEL TUBE
FABRICATED TUBULAR PARTS
WOLVERINE TRUFIN*
—the integral finned tube
REFRIGERATION AND AIR CONDITIONING TUBE (Plain or Tin Plated)
S.P.S. PIPE
SPUN-END TUBE†

*Reg. U.S. Pat. Off.
† A Patented Process RE 22465

Wolverine Trufin and the Wolverine Spun End Process available in Canada through the Unifin Tube Co., London, Ontario

WOLVERINE TUBE DIVISION
of CALUMET & HECLA, INC.
Manufacturers of Tubing Exclusively
1415 CENTRAL AVENUE • DETROIT 9, MICHIGAN
ESTABLISHED 1916
Plants in Detroit, Mich. & Decatur, Ala. *Sales offices in Principal Cities*
Export Department, 13 E. 40th St., New York 16, N. Y.



New 3-pole "E" Breaker. Also available in 1 and 2-pole models. 5-100-ampere rating, 5000-ampere a-c interrupting capacity. 240 volts a-c, 125/250 volts d-c.

100 AMP

New Westinghouse "E" Breaker Uprated from 50 to 100 Amps

GIVES TWICE THE CIRCUIT CAPACITY IN SAME CIRCUIT BREAKER FRAME SIZE

Here's a low-cost way to provide for increased power needs. The new Westinghouse 100-ampere "E" Breaker doubles circuit capacity *without increasing breaker frame size!* In lighting and distribution panelboards, switchboards and other enclosures, it saves critical mounting space—greatly expands capacity.

To maintain service on temporary peak overloads —yet, give instant short-circuit protection—"E" Breakers are equipped with thermal magnetic trip. Breaker cases are sealed after calibration—trip ratings are noninterchangeable, nonadjustable.

Standard Westinghouse AB Breaker features on this new line include: "De-ion®" method of arc extinction . . . non-welding silver-alloy contacts . . . corrosion-resistant bearings and parts . . . trip-free, quick-make, quick-break mechanism.

In a circuit breaker there's no substitute for sound engineering design and quality construction. Look to Westinghouse.

Call your Westinghouse Representative or write for Circuit Breaker Book B-5407, Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna.

J-30122

"Of Course, Circuit Breakers Save Money!"

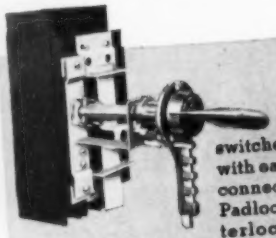
YOU CAN BE SURE... IF IT'S

Westinghouse

AB CIRCUIT BREAKERS

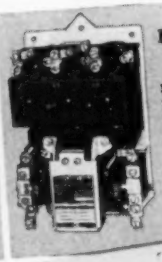
THE COMPLETE LINE

IT TAKES ALL 3 for



DISCONNECTS

Heavy duty industrial switches or circuit breakers, with easily installed safety disconnect handle mechanisms. Padlocking provision, and interlocking with door, safeguard personnel.

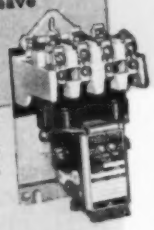


MOTOR STARTERS

Known throughout industry for maximum reliability and accessibility. Easily attached electrical interlocks save space and cost of separate relays.

CONTROL RELAYS

Compact without sacrifice of accessibility, wiring ease or reliability. 2 to 8 poles, convertible from normally open to closed.



TIMING RELAYS

Accurately timed delay periods assure proper machine sequencing. Rugged pneumatic timers give consistent performance over several millions of operations.

1 a COMPLETE line of components . . .

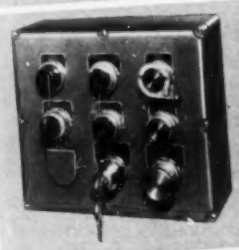
You can meet virtually any AC or DC application need by using standard Square D components. Each is designed to perform a specific control function—in minimum space—with maximum accessibility for easy inspection and maintenance. Each is physically proportioned for efficient and compact combination with other Square D components in building better, more attractive control panels.

CONTROL CIRCUIT TRANSFORMERS

Good transformer regulation maintains stable secondary voltage, even when energizing large solenoids or magnetic devices. New sizes extend range to 1000 VA.

PRESSURE SWITCHES

Adjustable pressure ranges from 1 to 3000 P. S. I. Drip-tight, oil-resistant enclosure houses sturdy mechanism and S. P. D. T. electrical contacts.



PUSHBUTTONS & ENCLOSURES

Heavy duty, oil-tight pushbuttons, selector switches and pilot lights in attractive cast enclosures harmonize with machine contours.

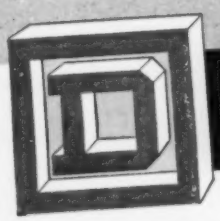
LIMIT SWITCHES

Compact enclosures exclude oil and dust. Easily adjustable operating arms and accessible terminals simplify installation.

DRUM SWITCHES

Attractively styled, compact case enhances appearance of machine. Switch is easily convertible from maintained contact to spring return.

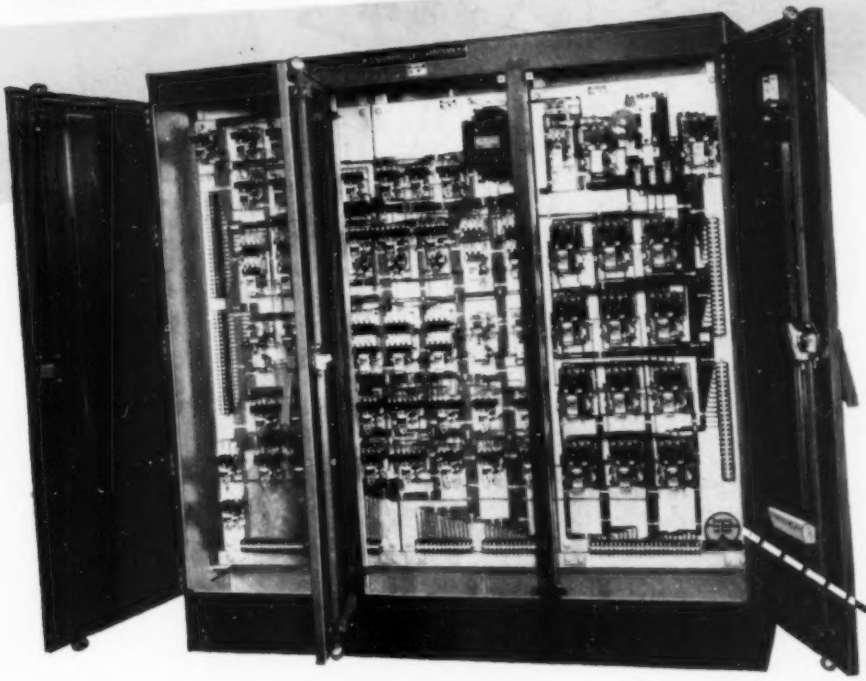
NEW!



SQUARE D COMPANY

1903 · **50** YEARS OF DESIGN LEADERSHIP · 1953

DESIGN LEADERSHIP IN MACHINE TOOL CONTROL



Engineered, Factory-Assembled and Tested by

SQUARE D COMPANY

2 Field Engineering . . .

Through seasoned Field Engineers, headquartered in more than 50 principal cities, Square D works "hand-in-glove" with machinery builders and plant engineers in solving electrical control problems. You'll like to work with them. They talk your language. They're backed by thorough factory engineering to assure the best possible selection of circuits and components.

3 Factory Assembly and Test . . .

No other electrical control manufacturer offers such complete and flexible facilities for designing and building custom equipment. If you don't have the complete story of Square D's new Job Shop operation, mail the coupon and we'll send it to you promptly.

SQUARE D COMPANY, Dept. 78
4041 N. Richards Street, Milwaukee 12, Wis.

Please send me a copy of your new booklet which gives the complete story of Square D's new **JOB SHOP OPERATION.**

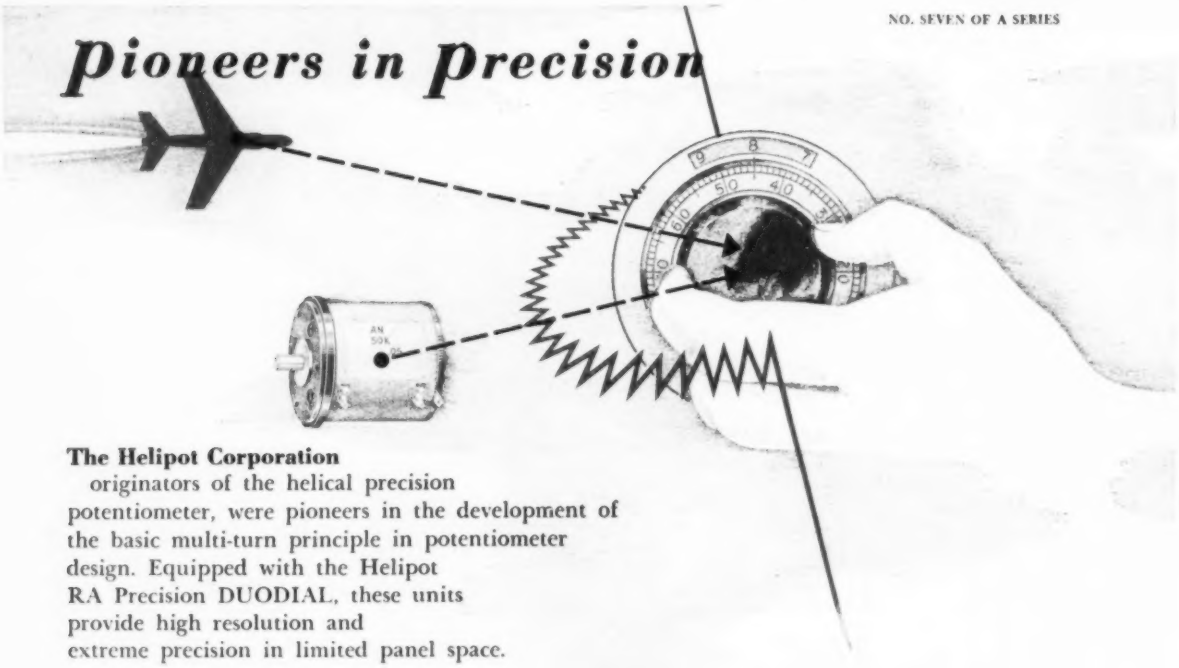
Name _____

Address _____

City _____ Zone _____ State _____

NO. SEVEN OF A SERIES

Pioneers in Precision



The Helipot Corporation
originators of the helical precision potentiometer, were pioneers in the development of the basic multi-turn principle in potentiometer design. Equipped with the Helipot RA Precision DUODIAL, these units provide high resolution and extreme precision in limited panel space.

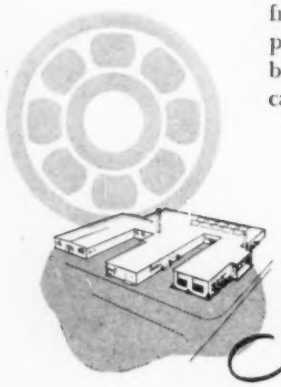
Miniature Precision Bearings

are the extra quality products manufactured by the originators and pioneer developers of ball bearings in miniature precision sizes. More than three thousand discriminating customers are currently being supplied with **MPB** components for applications involving high fidelity performance.

These fine quality **MPB** ball bearings are manufactured under exclusive and exacting production procedures as conceived and developed by **MPB** designers and engineers. Many designs and sizes of miniature ball bearings initially developed at **MPB** are now internationally standardized. Over a million **MPB** ball bearings have been installed in devices operating under unusual conditions . . . extreme temperature range . . . shock . . . continuous high load capacity . . . limited space in project miniaturization.

MPB ball bearings are fully ground, lapped, and/or honed to ABEC 5 tolerances or better. They are torque tested, ultrasonicly cleaned, supplied in specific tolerances and classified within the tolerances for prompt assembly and maximum service. **MPB** ball bearings are normally supplied in 10 series, from 1/10″ to 5/16″ o.d., of high carbon chrome bearing steel. Some are supplied in stainless and beryllium copper, and all are assembled with best quality balls. The most extensive engineering knowledge in miniature bearing applications is available to you. Write for Catalog and survey sheet PE3

Continued expansion, necessary in order to supply a steadily increasing demand for extra quality bearings, will soon enable us to participate in your future planning.



Miniature *precision* Bearings

Incorporated Keene, New Hampshire

"Pioneer Precisionists to the World's foremost Instrument Manufacturers"

save
space
weight
friction

GET OUR *Free* 6-PAGE FOLDER

See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. This attractively printed 8½ x 11" 6-page folder is punched for ring-binder use. You'll want to keep it handy for frequent reference. It contains 23 pictures of Small Gears, plant views, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!

SMALL GEARS *MASS-PRODUCED* TO HIGHEST QUALITY STANDARDS

A leading quality factor in mass-producing Small Gears is UNIFORMITY! The smallest micrometric variation in one Gear to another brings trouble—plenty of it. Mechanisms grind, strain, vibrate . . assembly lines stop abruptly. Delays, downtime, waste . . all play havoc with vanishing profit margins. You can avoid all danger of varying quality by making *us* responsible for the Fractional Horsepower Gearing you need. Like lots of other careful buyers, you too can capitalize on our 35 years of specializing in the *speedy, economical*, mass-manufacture of *better* Small Gearing exclusively. Tell us now about your needs. Call us in at the drawing board stage, or send samples, drawings, specifications. You'll like the sincere, friendly help we give.

FRACTIONAL HORSEPOWER

GS

GEAR

Specialties, Inc.

2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING

specify GRAPHITAR®

(CARBON-GRAPHITE)

proven successful in hundreds of difficult applications

GRAPHITAR bearings, seals, valves, vanes, bushings and other parts like these are helping to cut costs and improve the performance of a great many different products. Here are some important reasons why:

GRAPHITAR is lighter than magnesium yet mechanically strong and durable, with a compressive strength ranging from 4500 to 45,000 psi. It is available in varying degrees of hardness ranging up to that of hardened steel.

GRAPHITAR is practically unaffected by high speeds, high pressures or temperature extremes. Under extreme heat, GRAPHITAR will last much longer than most any other material because it cannot be melted below 6,000° F.

GRAPHITAR is self-lubricating. GRAPHITAR has a lower coefficient of friction than any other material. Even when lubricated with a very light fluid such as water, kerosene or alcohol, it will maintain a liquid film at the bearing surface under relatively high loads.

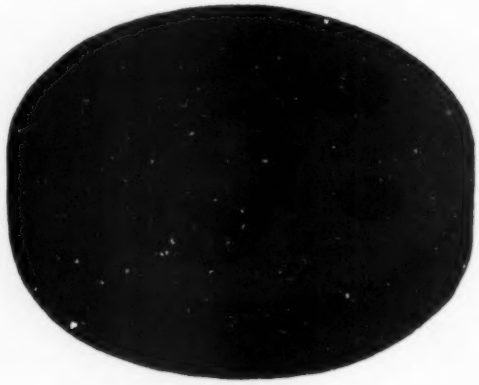
GRAPHITAR is chemically inert and will not corrode even when exposed to concentrated acids like hydrochloric or hydrofluoric.

GRAPHITAR is produced from many different types of carbon and graphite powders. It is available in many different grades and the porosity can be controlled to meet the requirements of specific applications.

GRAPHITAR can be formed in fairly intricate shapes and ground to tolerances as close as .0005". GRAPHITAR parts can be supplied in virtually unlimited quantities.

outboard motor pump bearing

steam valve rotor



automotive water pump seal

THE UNITED STATES

the versatile engineering material that has

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW, MICHIGAN

for *better* OIL STRAINERS in automatic transmissions

Cleaner oil betters performance, lengthens life. But an oil strainer can be no better than its wire cloth. So what? So *what* wire, or rather *whose* wire, makes a big difference.

Reynolds Wire Cloth is made to meet special-needs demands—all the way! From metal to mesh . . . from wire to weave . . . from ductility to durability. Its specifications are *your specifications*—its quality matches your products' quality. In any industrial application — automotive to agricultural.

Fifty-four—that's the measure of Reynolds wire cloth manufacturing experience, *in years.* By any other yardstick Reynolds measures up—from research to reliability. Put your problem to Reynolds engineers. No cost or obligation.

Automobiles

Trucks

Military Vehicles

Tanks

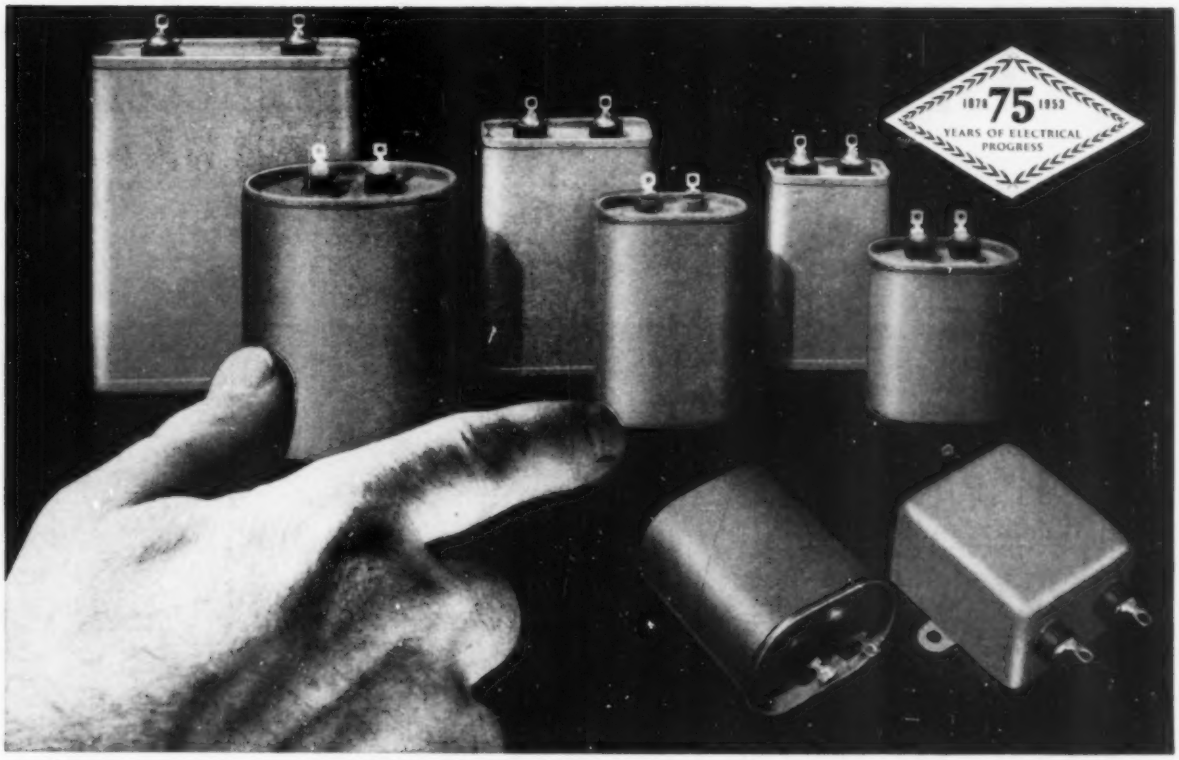
Locomotives

REYNOLDS WIRE DIVISION, NATIONAL-STANDARD CO., **DIXON, ILLINOIS**

Divisions of National-Standard Co.

ATHENIA STEEL...*Clifton, N. J.*.....Flat, High Carbon, Cold Rolled Spring Steel
NATIONAL-STANDARD...*Niles, Mich.*.....Tire Wire, Fabricated Braids and Tape
WAGNER LITHO MACHINERY...*Jersey City, N. J.*.....Metal Decorating Equipment
WORCESTER WIRE WORKS...*Worcester, Mass.*....Round and Shaped Steel Wire, Small Sizes

NS NATIONAL-STANDARD Company NILES, MICHIGAN



Photographic comparison of the new G-E Drawn-oval capacitors (in color) and the conventional units they replace, showing savings in size.

New General Electric Capacitor is Smaller, 10 to 20% Lower in Price

These fixed paper-dielectric hermetically-sealed capacitors offer:

- **Reduced costs—10 to 20%**
- **Savings in size and weight**
- **Double-rolled seams**
- **Drawn-steel cases**
- **Savings in critical materials**

If you're using fixed paper-dielectric capacitors with case styles CP53 and CP70 in ratings from 1 to 10 muf, 600 to 1500 volts d-c or 330 to 660 volts a-c—these Drawn-oval units offer you improved reliability in addition to an opportunity for reducing the size, weight and *cost* of the electrical equipment you manufacture.

In the new Drawn-oval capacitors, we get minimum seam length by using drawn-steel cases, attaching the capacitor covers with a double-rolled seam of proven reliability. This construction results in a lighter, yet stronger capacitor. Actual savings in size and weight vary with case style and rating but they can amount to as much as 30%.

This new construction has enabled us to increase output while eliminating some critical materials. The resulting savings are passed on to you in the form of shorter shipments and lower prices. Prices average 10 to 20% lower than standard capacitors, again depending upon case style and, of course, quantity ordered.

For more information on the new G-E Drawn-oval capacitors, their ratings, dimensions and prices, see your local G-E apparatus sales representative or write for Bulletin GEA-5777. Address Section 407-311, General Electric Company, Schenectady 5, N. Y.

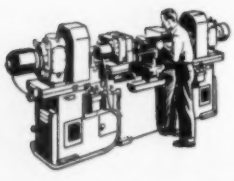
GENERAL ELECTRIC

LINK-BELT ball and

. . . keep company with

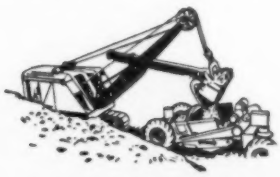
Latest design of the rugged Allis-Chalmers AD-40 Motor Grader includes Link-Belt Series DE self-aligning roller bearings. Allis-Chalmers relies on precision Link-Belt bearings on such other products as track-type and wheeled tractors, harvesters and balers.

LINK-BELT ball and roller bearings

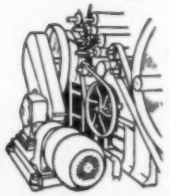


Metal Working Machinery

Farm Machinery



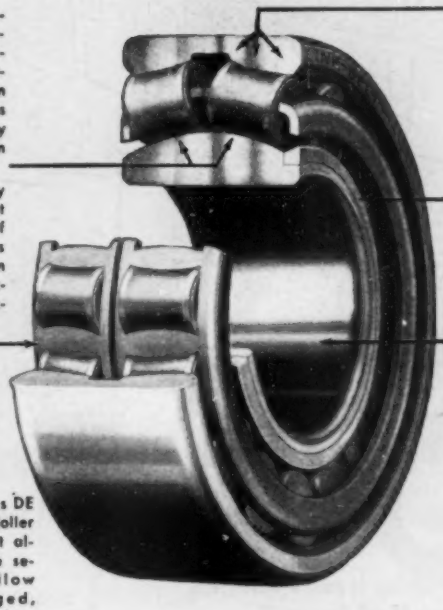
Construction Equipment



Textile Machines

roller bearings

America's hardest-working machines



Integral self-alignment—angular contact of concave rollers operating between convex raceways—inner raceway free to move in any direction.

Full load capacity for radial, thrust or combination of radial-thrust loads is assured even with shaft deflection or misalignment.

Accurately formed, hardened steel retainers space and guide the rollers.

Cutaway of Series DE Self-Aligning Roller Bearing. Link-Belt also offers a wide selection of pillow blocks, flanged, flanged cartridge, cartridge, hanger and take-up blocks.

Rollers are naturally positioned by their concave shape, assuring free rolling and eliminating end friction — no pinching or binding of rollers.

Bearing parts are assembled to proper clearance and locked together as a complete assembly.

Straight bore mounting for press fit direct on shafting. Tapered adapter sleeve also available for use with commercial shafting where ready means of removal and installation of bearing are advantageous.

LINK-BELT

BALL and ROLLER BEARINGS

IN addition to meeting industry's requirements for mounted ball and roller bearings, Link-Belt builds integrally self-aligning roller bearings. Concave rollers between convex raceways provide angular contact for ample capacity under *both* thrust and radial loading.

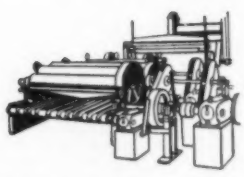
As on all Link-Belt bearings, precision manufacture assures you of long-life, free-rolling shaft support. Preadjusted for clearance at the factory and packed to reach you in "final inspection" condition, they require no adjustment when you're ready for installation.

Next time you specify bearings for one of your machines, call the Link-Belt office near you. They'll put you in touch with a Link-Belt bearing engineer who can give you expert advice on *any* bearing application. You can also get all the facts from Data Book 2550.

LINK-BELT COMPANY: Plants: Indianapolis, Chicago, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities.

13,110

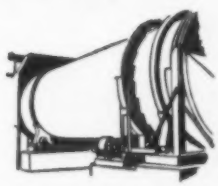
smooth the path of power for all industry



Pulp & Paper Machinery

Materials Handling Equipment

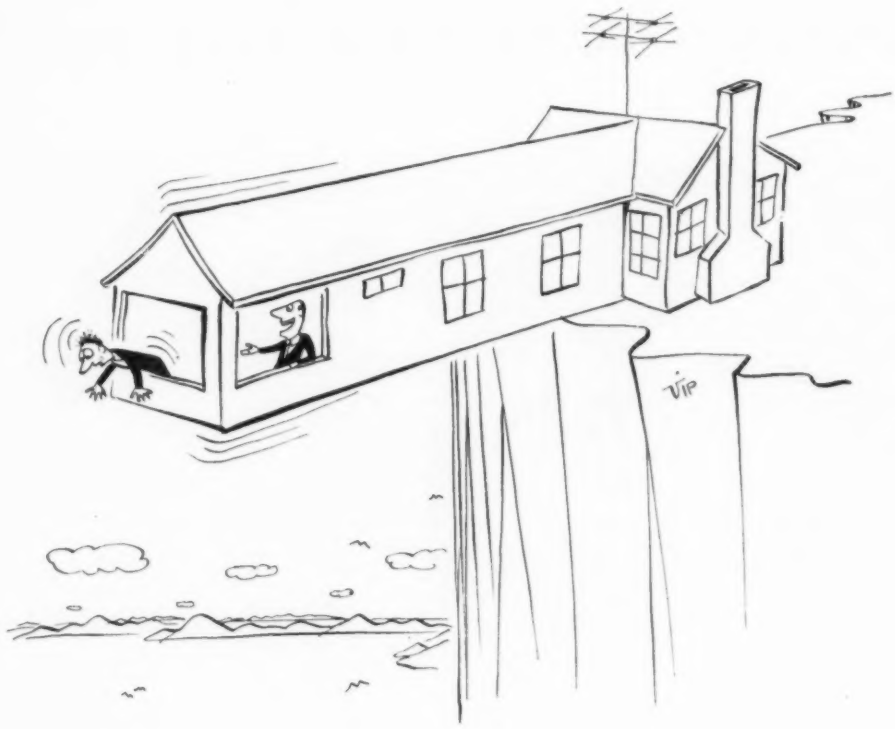
Oil Field Equipment



Processing Equipment

What's Screwy?

by Phillips



"Don't let it worry you. Everything is made fast with Phillips Cross-Recessed-Head Screws."

PERFECTLY MATED! Only Phillips Drivers are perfectly mated to Phillips Screws. Look for the name Phillips on the shank.

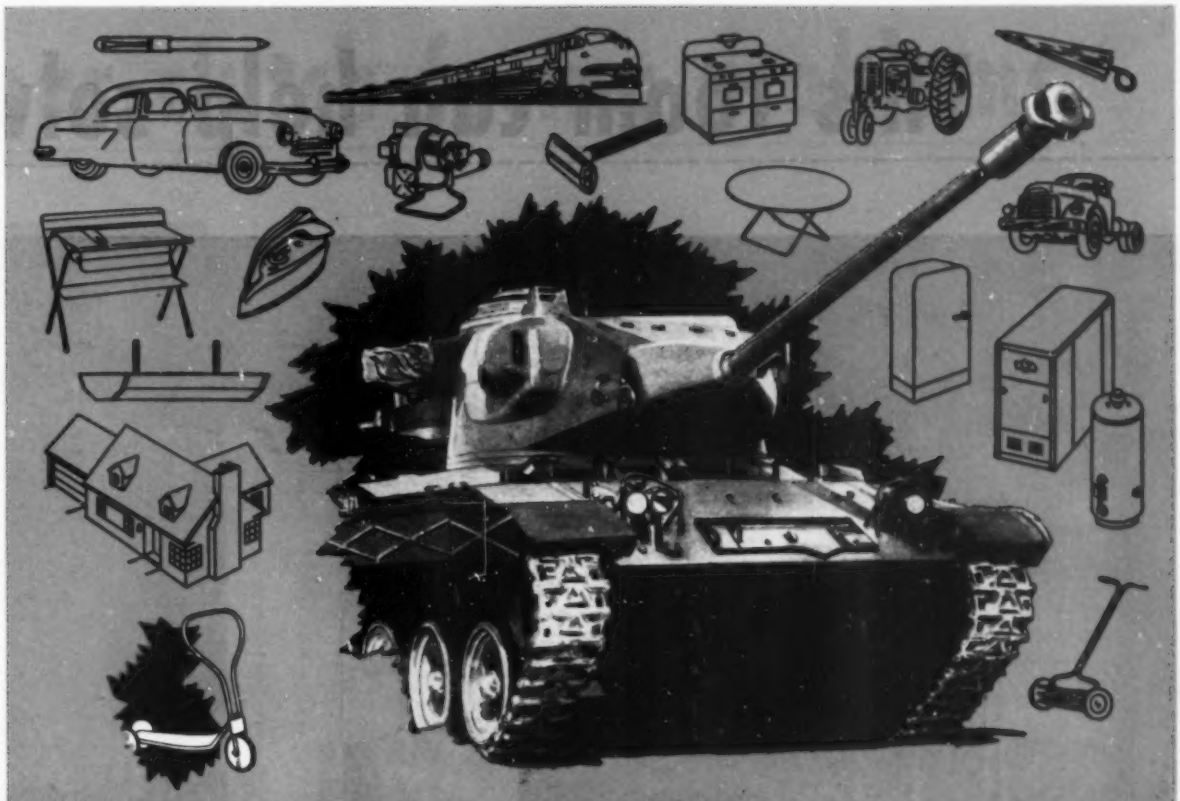
VIBRATION RESISTANCE because of added structural strength is only one of the exclusive advantages gained by using Phillips Screws. These screws set up tighter and their distinctive design gives them maximum strength of head. And that's not all. Because they are unusually easy to drive, they cut driving time up to 50%, eliminate driver skids and split screw heads. You save time, work, money when you use Phillips Screws — Wood, Machine, Tapping Screws or "Sems."

PHILLIPS *Cross-Recessed-Head* SCREWS

X marks the spot... the mark of extra quality

AMERICAN SCREW COMPANY • ATLANTIC SCREW WORKS, INC. • THE BLAKE & JOHNSON CO.
CENTRAL SCREW COMPANY • CONTINENTAL SCREW COMPANY • THE EAGLE LOCK COMPANY
ELCO TOOL AND SCREW CORPORATION • GREAT LAKES SCREW CORPORATION • THE H. M. HARPER CO.
THE LAMSON & SESSIONS COMPANY • NATIONAL LOCK COMPANY
THE NATIONAL SCREW & MANUFACTURING CO. • PARKER-KALON CORPORATION
PHEOLL MANUFACTURING CO. • ROCKFORD SCREW PRODUCTS CO. • SCOVILL MANUFACTURING CO.
SHAKEPROOF DIV. OF ILLINOIS TOOL WORKS • THE SOUTHINGTON HDWE. MFG. COMPANY
STERLING BOLT COMPANY • STRONGHOLD SCREW PRODUCTS, INC. • WALES-BEECH CORP.

TODAY'S... AND THE FUTURE'S... FINEST FASTENER



FROM TOYS TO TANKS

STEEL GM tubing

WIDE RANGE OF SIZES AND FINISHES

GM Steel Tubing is available in welded single wall or copper brazed double wall construction, in sizes from ⅛" to ⅜" O.D., and in straight lengths or in 120' to 1000' continuous coils. Choice of plain, Terne coated, copper plated, or Fuse-Kote (copper fused) finish.

EASILY FABRICATED

GM Steel Tubing not only lends itself readily to intricate bending but also to all types of fabricating operations—crimping, beading, perforating, swaging, expanding, drawing, flanging, flattening, knurling, threading. Rochester Products offers complete fabricating facilities, including the services of experienced General Motors engineers.

SOLVES PRICE AND PRODUCTION PROBLEMS

It's a far cry from a child's toy to a mighty weapon of war—yet GM Steel Tubing plays an important part in the design and building of both. In hundreds of other products, too, this low cost steel tubing serves to advantage either for the passage of liquids or gases, or as part of the mechanical structure.

Every day Rochester Products turns out *hundreds of miles* of GM Tubing in one of America's most modern and best equipped plants. Into every inch of its manufacture go the skill and engineering "know how" gained through nearly 20 years of General Motors research and development.

Whether you are designing new products or re-designing old ones, it will pay you to investigate the time-and-money-saving features of GM Steel Tubing.

SEND FOR FREE BROCHURE

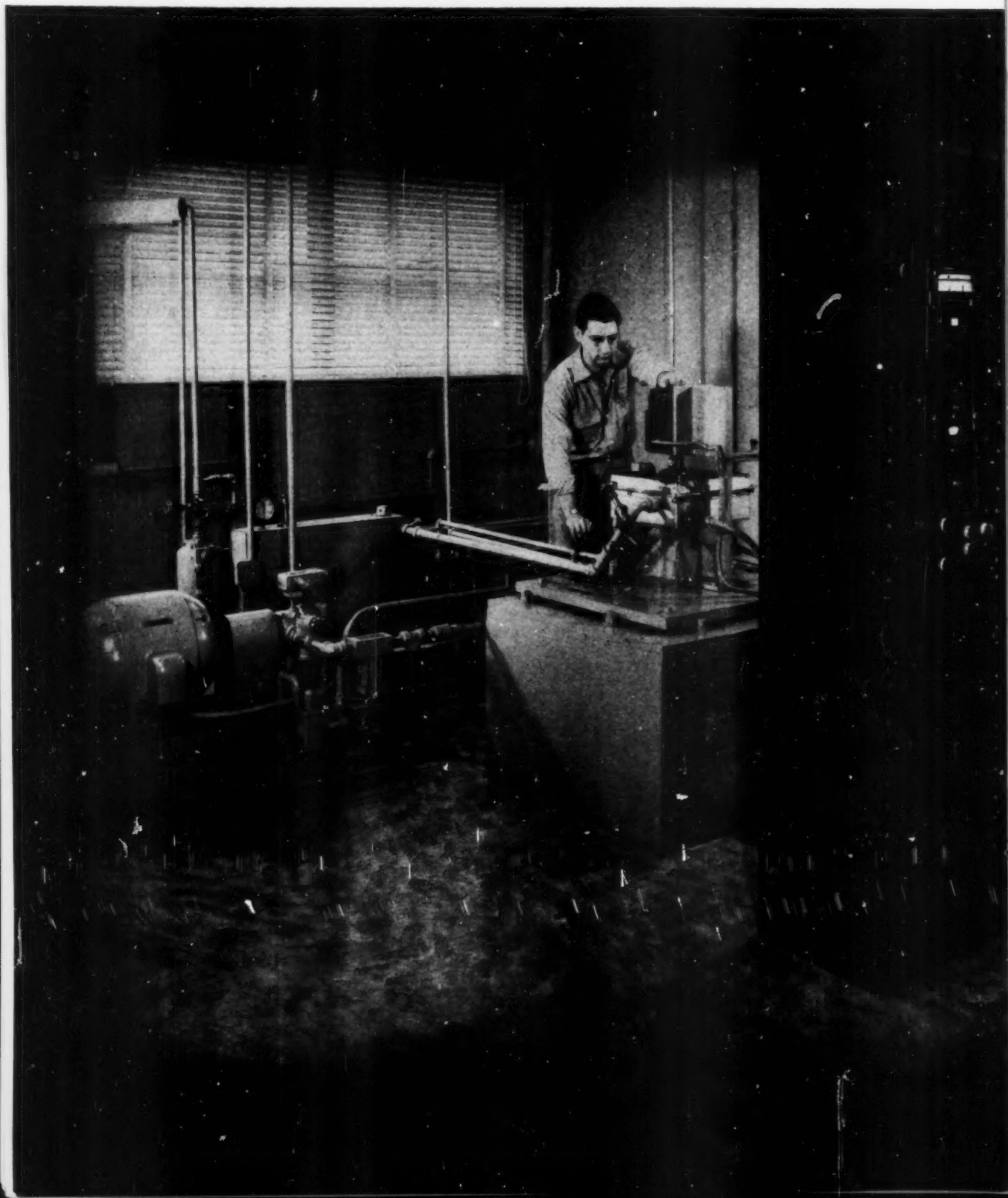
Our new illustrated brochure, entitled *"Look Ahead with GM Tubing,"* tells why GM Tubing is first in the field for lasting quality, adaptability and low cost. Send today for your free copy.

GM STEEL TUBING

ROCHESTER PRODUCTS *DIVISION OF GENERAL MOTORS*

Rochester, N. Y., U. S. A.

This room can help solve



your clutch facing problems

The equipment in this room, located at Armstrong's Research and Development Center, was specifically designed and built to give a new approach to the study of friction materials.

This equipment is Armstrong's Clutch Facing Test Machine . . . the best means yet devised to guide the development of friction material compounds.

With equipment like this and years of experience in compounding, Armstrong's engineers can modify our basic friction materials to answer practically any wet clutch problem.

Working with you, they'll help you find a facing material with the engaging characteristics, torque capacity, and service life you specify.

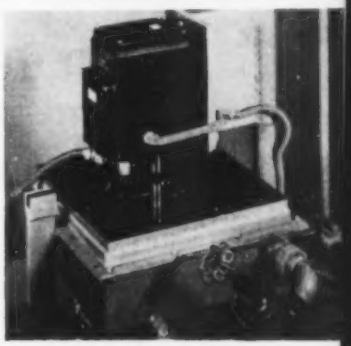
Today, facings of various types of cork compounds are being used on jobs ranging from heavy-duty automotive transmissions to electric typewriters.

Cork's inherent high coefficient of friction makes it an excellent material for friction drive applications. This frictional capacity permits lower face pressures, less slip, and smaller or fewer plates. Less slip means less temperature build-up and lower work loss. Engaging pressures from less than an ounce to loads up to 400 p.s.i. have been used successfully.

Let us help you take advantage of cork's many desirable characteristics. Whatever your wet clutch problem, we're ready to help you select a facing material designed to provide the unique combination of friction characteristics that your job requires.

In preparation now is an informative manual, "Armstrong's Friction Materials," full of helpful data on selecting the right facing material. You'll also find torque and deceleration curves for different compounds . . . a complete description on how you can use Armstrong's Clutch Test Facilities and a return check list on your clutch design to guide us in suggesting facing materials for test.

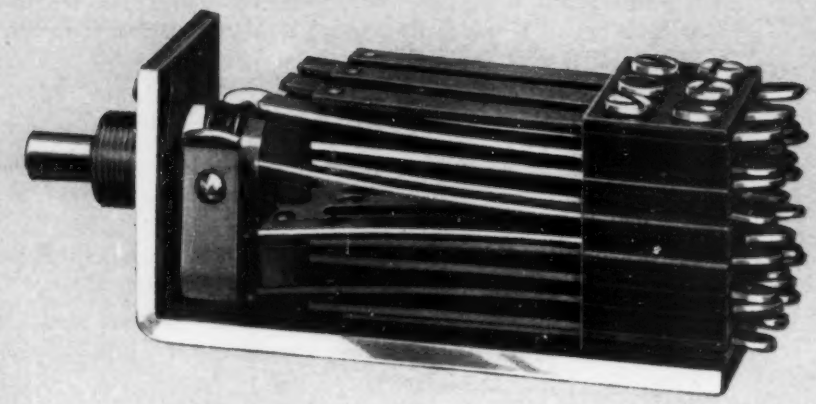
To reserve your copy of this manual, write to Armstrong Cork Company, Industrial Division, 1203 Areh Street, Lancaster, Pennsylvania. A copy will be sent as soon as it comes from the presses.



Close-up of part of Armstrong's Clutch Testing Facilities. Here, a full-size experimental automotive clutch submersed in oil permits evaluation of facing materials. Strain gages on the torque arm, shown at left of the unit pictured, are set up to record all test data on the main control panel.

ARMSTRONG'S FRICTION MATERIALS

Multiple Circuit Jack Switch Designed for 400,000 Detent Operations



Mallory experience produces precision jack switch to government design specification

With a single motion, this switch simultaneously connects a group of 12 circuits. It is designed with a single pole, single throw action per circuit. The actuating springs and cam springs are nickel silver. The contacts are fine silver.

This 12 circuit switch is representative of the wide range of special purpose switches manufactured by Mallory for exacting military requirements. Its precise construction is typical of the complete line of Mallory Jacks, Jack Switches and Plugs that are designed to fit an infinite range of circuit possibilities. They are sturdily built and will meet your most exacting specifications for performance and dependability.

For qualified engineering service and technical data on the application of Mallory Jacks and Plugs to communications, testing and many types of electronic and electrical equipment, call Mallory today.

Expect more... Get more from MALLORY

Television Tuners, Special Switches, Controls and Resistors

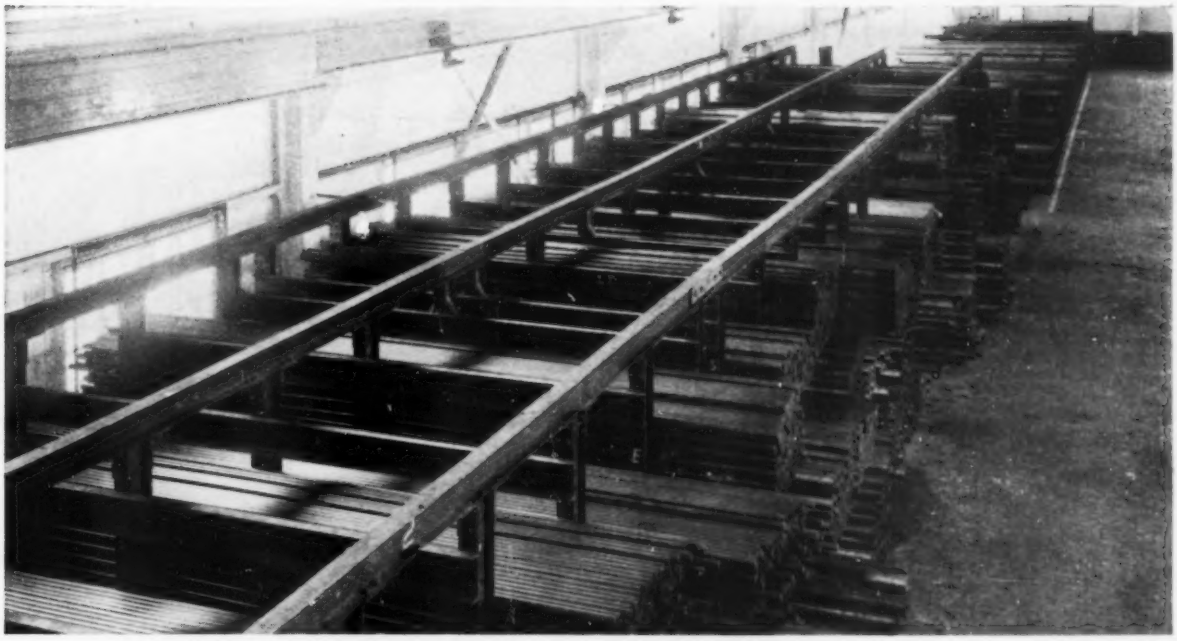
P. R. MALLORY & CO. Inc.

MALLORY

SERVING INDUSTRY WITH THESE PRODUCTS:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Dry Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

P. R. MALLORY & CO., INC., INDIANAPOLIS 6, INDIANA



=ORDER FOR 52100 TUBING RECEIVED TODAY.

WILL BE SHIPPED FROM MILL STOCK TOMORROW=

ORDER wear-resistant 52100 tubing today. We ship it tomorrow from our mill stock of one hundred and one sizes!

A high-carbon chrome steel, 52100 manufactured by the Timken Company, is through-hardening in moderate sections and can often be used in place of more expensive steels.

It can be heat treated to file hardness and tempered back to any desired point. And it's available in sizes from 1" to 10½" O.D., to fill many of your hollow parts needs: aircraft parts, ball bearing races, pump parts and plungers, collets, bushings, spindles, grinding machine parts and precision instrument parts.

As America's first producer of 52100 tubing, the Timken Company has unequalled experience that results in uniform high quality from tube to tube and order to order. Rigid quality control checks every step of production.

For immediate delivery of your less-than-mill-quantity orders, write, wire or call The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

SPECIFY

GRAMIX®

SINTERED METAL PARTS AND BEARINGS, OIL IMPREGNATED FOR SELF LUBRICATION IF DESIRED

SAVE TIME MONEY AND MATERIAL

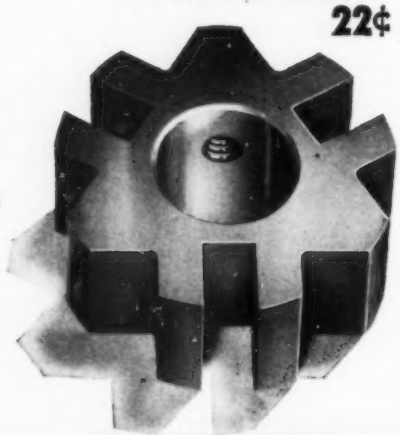
DOUBLE IRON PULLEY 32¢

IRON PIVOT BEARING 22¢

NICKEL SILVER CAM 9¢

BRONZE SPHERICAL BEARING 6¢

BRONZE YOKE LINK 14¢



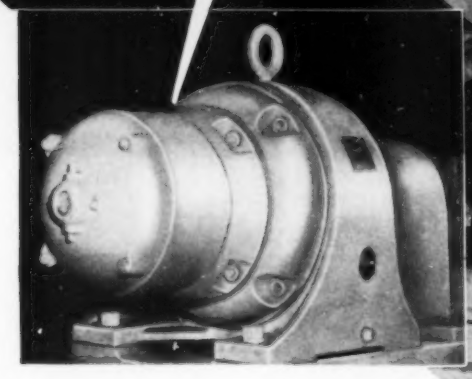
IRON HUB SPROCKET 85¢

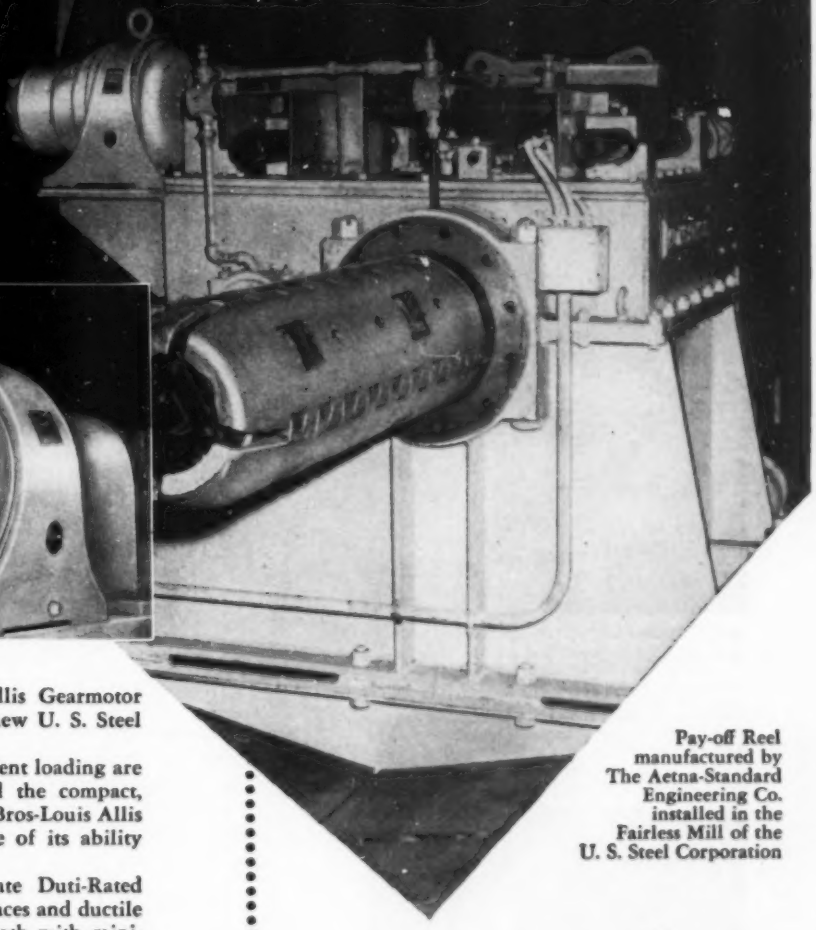
92

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

when a job takes guts here's the gearmotor that has it . . . .





Here's a Foote Bros.-Louis Allis Gearmotor Driving a pay-off reel at the new U. S. Steel Fairless mill.

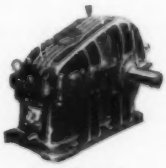
Rugged service and intermittent loading are characteristics of this job and the compact, low-cost, highly-efficient Foote Bros-Louis Allis Gearmotor was chosen because of its ability to render that service.

These gearmotors incorporate Duti-Rated Gears, with file-hard tooth surfaces and ductile cores, assuring maximum strength with minimum size and weight. Available in single, double and triple reductions, to provide output speeds of 780 down to 7.5 r.p.m.

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard • Chicago 9, Illinois

Hygrade Drives

Line-O-Power Drives



Maxi-Power Drives

Pay-off Reel manufactured by The Aetna-Standard Engineering Co. installed in the Fairless Mill of the U. S. Steel Corporation

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. W, 4545 S. Western Boulevard, Chicago 9, Illinois
Please send me Bulletin GMA containing full information on Foote Bros.-Louis Allis Gearmotors.

Name.....

Company.....

Address.....

Position.....

City..... Zone..... State.....

THEY SAY THAT SOME SHEAVES CAN EASILY BE MOUNTED IN ONE PIECE AND GIVE THE SAME SHAFT GRIP AS THE TWO-PIECE DESIGN
NO, CHARLIE... LISTEN- THE SHEAVE THAT GRIPS THE SHAFT TIGHTEST IS THE ONE THAT'S DESIGNED TO BE MOUNTED IN TWO PIECES!

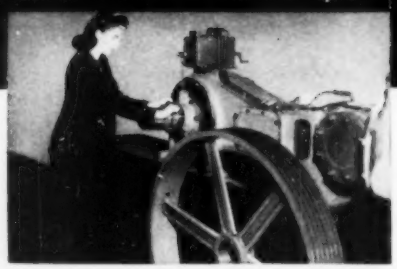


FIGURE 1—TO MOUNT THE QD IN TWO PIECES you (1) slide the split hub on the shaft, (2) position it with the locking clamp-screw in the flange, (3) draw down on the set-screw over the key (QD exclusive) to prevent it from drifting, (4) slide the QD rim with its large taper bore opening up on the taper of the hub, (5) draw up on three heavy hex-head pull-up bolts for a tighter grip than you get with any other sheave.

FIGURE 2—TO MOUNT THE QD AS A UNIT where a Woodruff key is used in a shouldered shaft, you (1) locate the loosely assembled hub and rim of the QD sheave against the shaft shoulder and (2) draw up on the three heavy hex-head pull-up bolts. That's all there is to it. And you haven't sacrificed any grip on the shaft. For removal, you simply use pull-up bolts as jack bolts in specially tapped holes.

Let's settle this one RIGHT NOW!

You can't have your cake and eat it too.

A one-piece sheave assembly may grip the shaft sufficiently tight for average use, but it *won't keep the shaft key from drifting*. Your answer to this problem lies in an *exclusive* key set-screw in the hub of the *two*-piece Worthington QD* Sheave. The set-screw is tightened with the hub on the shaft before the rim is slipped on (figure 1).

Of course, if you use a Woodruff key in a shaft with a shoulder, drifting of the key is no problem and you then can mount the Worthington QD assembled in *one* piece *without any sacrifice of its famous friction-cone grip* (figure 2).

WORTHINGTON'S COMPLETE LINE OF MULTI-V-DRIVES includes QD sheaves in all sizes, QD Juniors and other fractional horsepower V-pulleys, as well as Worthington-Goodyear V-belts. Your distributor has complete stocks backed by the largest factory stocks you'll find anywhere. Write for Bulletin V-1400-B71' to Worthington Corporation, Oil City, Pennsylvania.

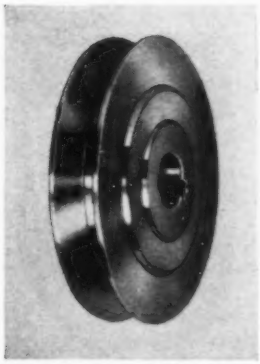
*Reg. U. S. Pat. Off.

The QD Junior V-Pulley for fractional-hp applications offers all the advantages of its big brother

TRADE MARK

Here's the popular Worthington QD principle applied to a fractional-hp V-pulley! It will grip the shaft tighter than any other V-pulley now available. The cutaway shows how tightening of the large nut causes the taper-bored rim to force the tapered hub *tight* on the shaft. Removal is just as simple.

No matter what your fractional-hp V-pulley needs WORTHINGTON has an answer . . .

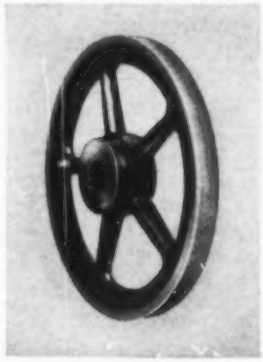


Machined Steel V-Pulleys —3½ in. and under

Precision-bored for proper fit on shaft. Belt seats properly, wears longer in accurately cut groove.

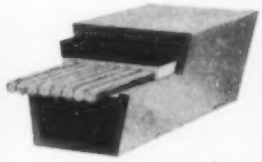
Pressed-Steel V-Pulleys

Heavy gauge, welded steel. Equal weight distribution assures accurate balance and vibrationless operation.



Cast Iron Bored-to-Suit V-Pulleys

Accurately machined for true running and perfect balance. Full range of sizes with one or two grooves.



For smoothest performance from V-belt drives use WORTHINGTON-GOODYEAR EC Cord V-belts

Each cord carries its equal share of the belt load, each belt—its equal share of the drive load. A complete line. Also steel-cable belts for high capacities, HY-T cord belts for shock loads, and FHP belts.

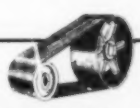
GET MORE OF THE FACTS

For all the facts write today for: Bulletin V-1400-B7F on stock sizes and specifications of Worthington QD sheaves and Worthington-Goodyear V-belts. Bulletin FHP-100 on FHP pulleys and V-belts. Worthington Corporation, Oil City, Pa.

MV.2.13

COMPRESSORS: AIR-COOLED, WATER COOLED

PUMPS: CENTRIFUGAL, ROTARY, STEAM, POWER



MULTI-V-DRIVES: QD SHEAVES AND V-BELTS

VARIABLE SPEED DRIVES: ALLSPEED DRIVE, ALLSPEED MOTOR DRIVE

WORTHINGTON

Multi-V-Drives

Specify These Worthington Standard Products on Your Equipment

when the call comes for a change in shape, size or material . . . machines equipped with

REEVES

Variable Speed Drives make the "changeover" easier! faster! cheaper!

In many plants only partially converted to defense production, the machines you build are being called upon to turn out military supplies part of the time and civilian products the rest of the time. Today they may be producing a part made of steel, but tomorrow the schedule may call for an aluminum part of different shape and size.

These conditions place a premium on machines with top "changeover capacity" . . . machines that can be shifted quickly and economically from job to job—from one shape, size or material to another.

That's what REEVES Variable Speed Drives can do for the machines you build. Give them *extra* "changeover capacity" by providing the right speed—with the turn of a handwheel, touch of a button, or automatically, without stopping the machine—for each different product or material.

REEVES stepless speed adjustability pays another important bonus, too—because it permits machine speed to be adjusted to match the skill of the individual operator. Beginners can work slowly while learning —a protection for costly machinery. Skilled operators can work at high speed. But, *always,* uniform quality is maintained.

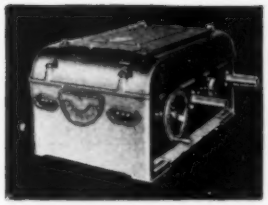
REEVES Variable Speed Drives—now standard equipment on 2,615 leading makes of machines—can be incorporated easily in your new designs because REEVES is the only complete line of variable speed drives in existence. Built around the three basic units shown opposite, it offers a wide selection of horsepower capacities, speed ratios and designs—with manual, electric, and completely automatic hydraulic or mechanical controls.

An experienced REEVES Speed Control Engineer will be glad to give you complete details in relation to your own particular requirements. Write for his name—no obligation, of course.

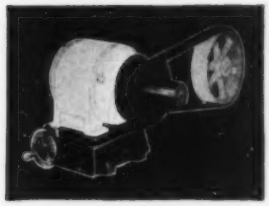
REEVES PULLEY COMPANY • COLUMBUS, INDIANA

Recognized leader in the specialized field of speed control engineering

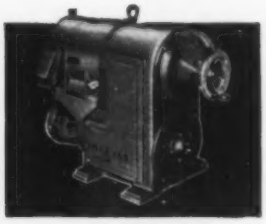
for the machines you build, your choice of these three basic REEVES units



VARIABLE SPEED TRANSMISSION provides infinite, accurate, stepless speed adjustability over a wide range—as high as 16 to 1. Sizes to 87 hp.

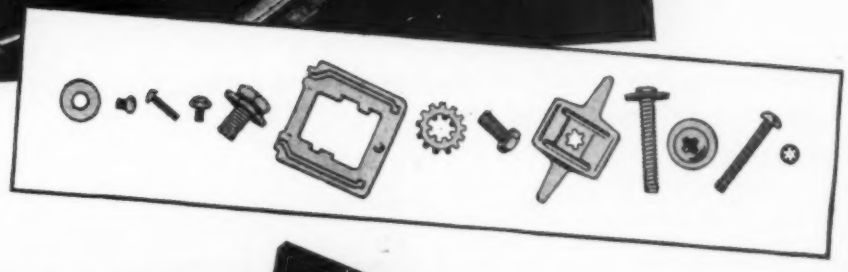


VARI-SPEED MOTOR PULLEY converts any standard, constant-speed motor to variable speed drive. Speed variations to 4 to 1. Sizes to 10 hp.



VARI-SPEED MOTODRIVE combines motor, speed-changing mechanism and gear reducer in one unit. Speed variations as great as 10 to 1. Sizes to 25 hp.

A REEVES Vari-Speed Motor Pulley drives the conveyor to provide accurate time control for each of these six continuous draw furnaces installed in the Elgin (Ill.) plant of Shakeproof Inc.—a Division of Illinois Tool Works. Manufactured by Sunbeam Stewart Industrial Furnace Div., Sunbeam Corp., Chicago, the REEVES-equipped units provide close control in order to assure proper heat treatment, at highest production rate, for each of the many metal fastenings processed, some of which are shown in the inset photo, below.



accurate · variable **REEVES** *Speed Control*

Ask for complete information, including engineering drawings and technical data, on the full line of REEVES Variable Speed Drives and Controls. Send for catalog No. K73b-3N.

The unique Lord application illustrated above accommodates controlled orbital motion of the sanding head in the Porter-Cable #106 Finishing Sander. "Lord Bonded-Rubber Mountings", Porter-Cable reports, "outlast any mountings previously used because of the excellent bond between rubber and metal" and thus contribute much to the efficient operation of this popular Porter-Cable unit. You may have a similar problem to solve in the products you manufacture. Your request for information is invited. We will be pleased to consult with you on the application to your products of Lord Vibration and Shock Control Mountings and Bonded-Rubber parts.

BURBANK, CALIFORNIA	DALLAS, TEXAS	PHILADELPHIA 7, PENNSYLVANIA	DAYTON 2, OHIO
233 South Third Street	413 Fidelity Union Life Building	725 Widener Building	410 West First Street
DETROIT 2, MICHIGAN	**NEW YORK 16, NEW YORK**	**CHICAGO 11, ILLINOIS**	**ERIE, PENNSYLVANIA**
7310 Woodward Ave.	280 Madison Avenue	520 N. Michigan Ave.	1635 West 12th Street

LORD MANUFACTURING COMPANY • ERIE, PA.

LORD BONDED RUBBER — *Headquarters for* **VIBRATION CONTROL**

(Advertisement)

Lord Mountings Perform Unique Function On Porter-Cable Portable Sander

One of the most unusual requirements for the application of Lord Bonded-Rubber parts is that of the Porter-Cable Portable Sander 106. Here the orbital action of the sanding component must be held within certain limits by the use of flexible rubber mountings fixed to the four corners of the upper housing and the sanding component. High speed operation is necessary for achieving the desired smoothness of surface on materials to be sanded.

Previously used mountings worked well for a time and then failed. The problem of longevity was put up to Lord Headquarters for Vibration Control in Erie, Pa.

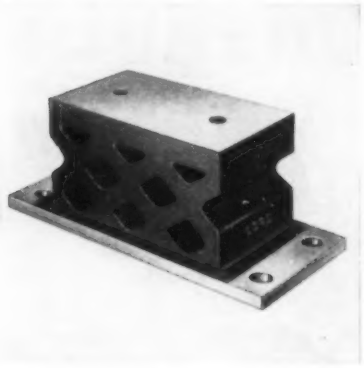
Analysis of the problem showed that the correct rubber compound bonded to threaded metal studs would offer the desired flexibility with reasonable possibility of longer service life and subsequently less failures. Many tests were completed before adopting the mounting shown in the accompanying advertisement. All objections to the operation of previous mountings were removed by this consultation with Lord Engineers and the results of their efforts. This is but another of many such typical solutions of the vibration problems of appliance manufacturers. These problem solutions include correct mounting of spin dryers on automatic washing machines, isolation of transmitted vibration through fan hubs of room air conditioners, the mounting of mixing and blending equipment used by the modern housewife—in fact, wherever vibration and shock present an obstacle to satisfactory machine operation Lord Vibration Control Mountings are being engineered for the job. The experience of more than a quarter century in dealing with vibration and shock problems is available to you in the solution of vibration problems. Your efforts to improve the operation of your product by controlling or isolating vibration will be more effective when you consult with Lord Manufacturing Company, Erie, Pa.

(*Advertisement*)

New Lord Lattice Mounting Used To Advantage On Heavy Industrial Machines

The Lord lattice mounting incorporates many features of value to designers of heavy industrial equipment. These mounts are now being used for support of Foundromatic Shakeouts and Aero-Vibe Screens manufactured by Allis Chalmers. Other applications include reciprocating or rotating machinery requiring a high degree of vibration isolation. The load range for a lattice type mounting is 250-2000 pounds per mounting point.

The lattice design of the rubber section permits the load to be carried by the rubber in shear . . . the softest practical type of support. Lattice type mountings offer more stability in the horizontal plane. No lubrication is required thus lowering maintenance costs. Since there are no steel surfaces in contact, quieter operation is possible. The rubber section also offers greater isolation of noise that is easily transmitted through steel springs. The inherent damping of the rubber reduces the excursion of screen in passing through resonance on starting and stopping. No mechanical dampers are required.



The lattice type mounting offers excellent vibration isolation for the lower range of disturbing frequencies. For very low operating speeds, the mountings may be installed in series. The lattice type mounting also accommodates large amplitudes of motion.

The lattice design is another instance where Lord experience in vibration and shock problems has proved valuable to manufacturers. Consult with Lord engineers early in the design phase of your products. Lord's vast reservoir of experience is yours for the asking.

Lord Bonded-Rubber Lattice Mounts are used for support of Foundromatic Shakeouts and Aero-Vibe Screens manufactured by Allis-Chalmers. The lattice design permits the load to be carried by the rubber in shear—the softest practical type of rubber support. Installed under the machine, the lattice mounting eliminates the overhead supporting structure necessary with the overhead coil spring suspension system.

This is another illustration of how Lord Bonded-Rubber parts are being used profitably in many industries. Consult with Lord engineers on your vibration or shock problems. We invite your inquiry.

BURBANK, CALIFORNIA	**DALLAS, TEXAS**	**PHILADELPHIA 7, PENNSYLVANIA**	**DAYTON 2, OHIO**
233 South Third Street	413 Fidelity Union Life Building	725 Widener Building	410 West First Street
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LORD BONDED RUBBER

Headquarters for
VIBRATION CONTROL

KLIXON *Thermo Snap* CONTROLS

Provide Dependable Temperature Control in York-Shipley Boiler Units

York-Heat oil-fired table-top boiler units, manufactured by York-Shipley, Inc., York, Pa., are designed to do an outstanding job of home and hot water heating.

To insure accurate temperature control, York-Shipley uses Klixon Thermo-Snap Controls in all their units. Mr. H. Leroy Mohn, project engineer, writes: "*We insist on Klixon Thermo-Snap Thermostats in our house heating boilers because we find they accurately control unit operation. Klixon C4370 thermostats are used to control the operation of burners and circulators to automatically govern the temperature of the home and domestic hot water.*"

What's your temperature control problem . . . low and high limit controls, fuel delay switches, tube and rectifier cooling, fan switches, temperature control . . . Klixon Thermo-Snap Controls are meeting the requirements for these and other applications in military and civilian products, daily.

Klixon Thermo-Snap Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

Klixon Engineers, specialists in temperature control applications, can help you solve your specific problems. Write for their help or further information.

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Division of Metals & Controls Corporation

903 FOREST STREET, ATTLEBORO, MASS.

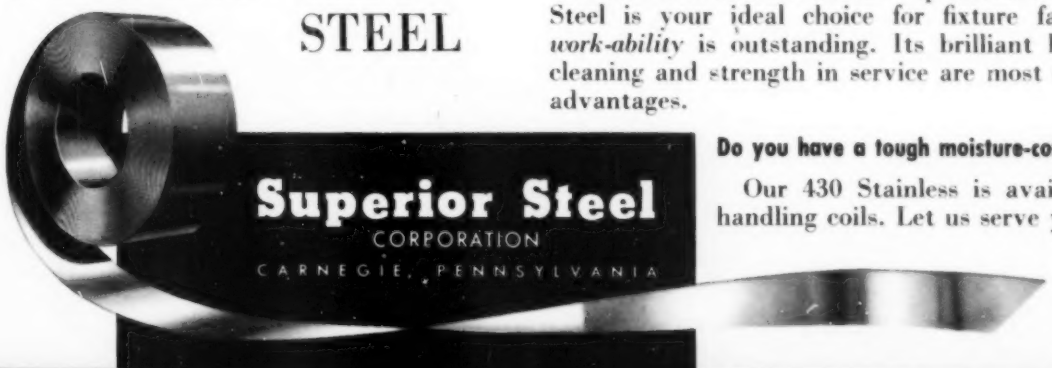
TYPICAL KLIXON THERMO-SNAP CONTROLS THAT CAN HELP SOLVE YOUR TEMPERATURE CONTROL PROBLEMS

Beauty **at work**... in today's bathrooms

Superior

TYPE 430 STAINLESS STRIP STEEL

The luster of Superior 430 Stainless Strip Steel conveys more than sparkling beauty in the bathroom. Its brilliance speaks of triumph over rust and corrosion, where dampness and moisture abound. • Superior 430 Stainless Strip Steel is your ideal choice for fixture fabrication. Its *work-ability* is outstanding. Its brilliant luster, ease of cleaning and strength in service are most desirable sales advantages.



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CORPORATION
CARNEGIE, PENNSYLVANIA

Do you have a tough moisture-corrosion problem?

Our 430 Stainless is available in easy-handling coils. Let us serve you!

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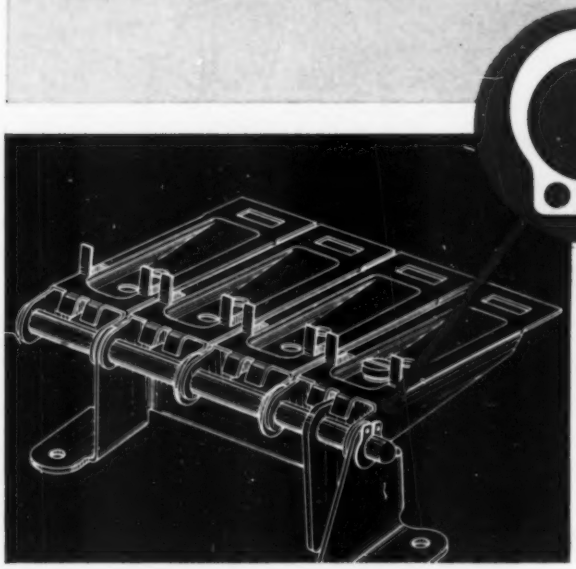
SPHERICAL BEARING ROD ENDS . . . .

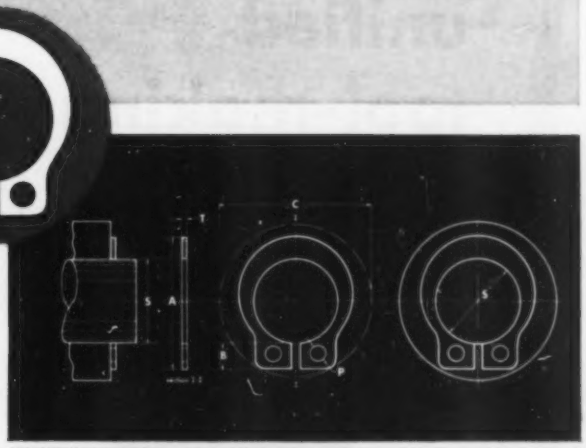
From grass roots to depths as great as 6000 feet, Bucyrus-Erie Spudders combine big capacity with hard-hitting, fast drilling action. Operating steadily for a year and a half without being down a single hour for repairs, the result of simple, durable design of the machine and its component parts . . . such as the Heim Unibal Spherical Bearing Rod Ends.

HEIM UNIBAL BEARINGS AND ROD ENDS ARE AVAILABLE IN A WIDE RANGE OF STOCK SIZES . . . WRITE FOR CATALOG.

THE **HEIM** COMPANY
FAIRFIELD, CONNECTICUT

New Waldes Truarc GRIP Ring requires no groove, holds fast by friction, can be used over and over again





Ring # 5555		5555-12	5555-13½	5555-18	5555-25	5555-31	5555-37
SHAFT DIAMETER	Fract. Equiv. S	1/8"	—	3/16"	1/4"	5/16"	3/8"
	Dec. Equiv. S	.125	.136	.187	.250	.312	.375
	TOL.	±.002	±.002	±.002	±.002	±.003	±.003
RING DIMENSIONS	Thickness T	.025	.025	.035	.035	.042	.042
	TOL.	±.0015	±.0015	±.002	±.002	±.002	±.002
	Length A	.268	.285	.364	.437	.553	.626
	Lug B	.078	.078	.097	.097	.141	.141
	Hole P	.042	.042	.042	.042	.078	.078
	Min. Ring Clear C	.33	.34	.44	.50	.67	.73
Approx. Ultim. Thrust Load (Lbs)		20	20	25	35	50	60

The Waldes Truarc Grip Ring is a new, low cost fastener that provides a positioning shoulder secure against moderate thrusts or vibration. Installed on a straight ungrooved shaft, the Truarc Grip Ring can be assembled and disassembled in either direction with Truarc pliers.

The Grip Ring can be installed tightly against a machine part in order to take up end-play. The basic Truarc design principle assuring complete circularity around periphery of the shaft and the ring's unusually large radial width combine to exert considerable frictional hold against axial displacement. The ring can be used again and again.

Find out what Waldes Truarc Retaining Rings can do for you. Send us your drawings. Waldes Truarc engineers will give your problems individual attention without obligation.

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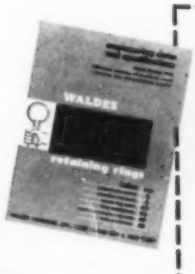

Waldes Kohinoor, Inc., PN-035
47-16 Austel Place, L.I.C. 1, N. Y.

☐ Please send me sample Grip-Rings (please specify shaft size _____)

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. . . proved-performance

tooling

Do you have to sweat out your own tooling problems?

Or, worse yet, do you have to farm out the work piece-meal?

Either way, it will pay you to investigate Kirksite Stamping Tool Service . . . a service *complete in every respect.*

In one unified operation, we can take your problem off your hands right from the idea, sketch, blueprint or model stage. We can make and finish patterns and dies. Then from these we can turn out try-out stampings or moderate production runs . . . *all in the same shop.*

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All in all, the Kirksite "package" means fewer headaches . . . quicker production . . . lower costs!

If you make aircraft stampings, automotive vehicles, business machines; any die stamped parts, in fact, you ought to know more about this service. Write for "Kirksite," a free new booklet that gives you the up-to-the-minute facts on this complete service to cut tooling costs . . . tooling time. Address: National Lead Company, Kirksite Division, 900 West 18th St., Chicago, Illinois.

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SOLVING COMMON GASKET PROBLEMS

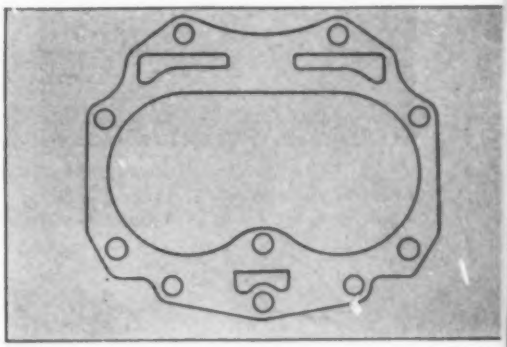
. . . with Accopac

Three interesting applications of Armstrong's new fiber gasket material

APPLICATION: Oil cup seal on power lawn mower

PROBLEM: Temperatures of 250°—300° F. demanded a heat-resistant gasket. However, the compressed asbestos-neoprene gaskets that were being used were too hard to permit a tight enough seal with thumb-screw pressure.

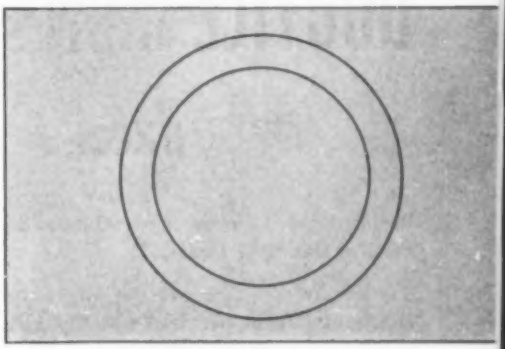
SOLUTION: To get the compressibility he needs for a tight seal under light flange pressure, this manufacturer now uses 1/16" Accopac® AN-702 (asbestos). In addition to its unusual compressibility, Accopac has excellent heat resistance . . . and won't harden and shrink when exposed to hot oil.



APPLICATION: Cylinder-to-case gasket on tractor

PROBLEM: Conventional glue-glycerine material was leaking badly. Hot lubricating oil was causing excessive gasket shrinkage. In addition, severe vibration often ruptured the gasket.

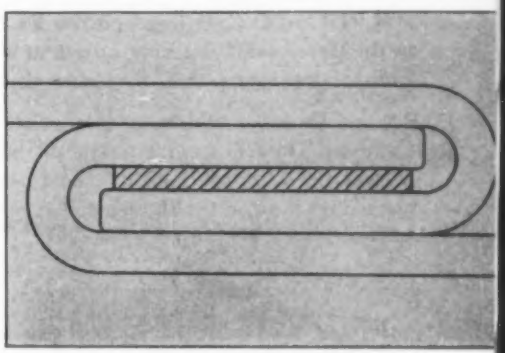
SOLUTION: Accopac CN-705 (cellulose) was tested as a replacement. Specifications called for at least 200,000 test cycles of leak-free performance. When tests were ended, Accopac had shown no signs of weakness in 569,000 cycles. This company's engineers say of Accopac, "It's the best fiber gasket we ever tested."



APPLICATION: Wall panel seal for textile drier

PROBLEM: Drier temperatures often reach 700° F. To eliminate heat loss caused by air leakage between sections, this manufacturer needed a compressible, impervious material capable of withstanding the high temperatures.

SOLUTION: Accopac AN-702 (asbestos) was tried. Because of its good compressibility and heat resistance, a 1/64" strip of Accopac almost completely eliminated air leakage—and heat loss. The flexibility of asbestos Accopac means easy handling on the job and eliminates a major source of leaks.



Send for this helpful booklet

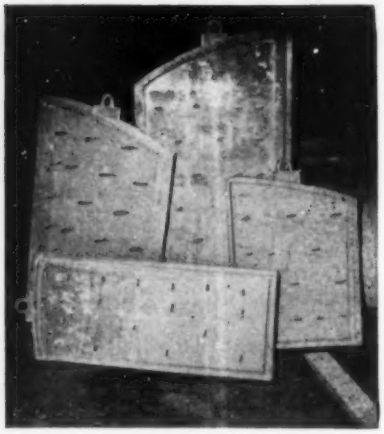
Try Accopac when you need something extra in a fiber gasket. This new material is made by an improved beater saturation process that locks each fiber in an even coat of rubber.

Accopac's strong, uniform composition gives it high crush resistance (100,000 psi), a wide range of compressibility, good dimensional stability, and imperviousness. Heat or fluid action won't cause Accopac to dry out and crack or shrink. A free booklet, "Armstrong's Gasket Materials," gives full information on Accopac. For your copy, call your nearest Armstrong Industrial Div. office or write Armstrong Cork Company, Industrial Div., 6203 Arch St., Lancaster, Penna.

ARMSTRONG'S ACCOPAC

COMPARISON OF GRATE MATERIAL

Gray iron sintering grates, at left, show bad scaling and warpage after a single month of use. Note good shape of Ductile Iron grates, above, after same service. They greatly outlasted gray iron grates.



DUCTILE IRON FURNACE DOORS SAVE MONEY, TIME AND LABOR—In ordinary iron, exposed to high temperature, internal oxidation easily penetrates along paths of flake graphite, thus causing destructive growth. Penetration is curbed in Ductile Iron, since its graphite is wholly in spheroidal form.

DUCTILE IRON Sintering Grates and Furnace Doors *excel in elevated temperatures*

Performance Records Show Outstanding Heat-Resistance of this New Material.

Tests show that iron containing graphite wholly in spheroidal form provides notably greater growth resistance than ordinary gray iron.

FOR INSTANCE: Gray iron and Ductile Iron grate bars in the Greenawalt sintering system of a merchant pig-iron producer gave the following performances:

At the Canadian Furnace Company, Ltd., in Port Colborne, Ontario . . . from date of their installation, August 1950, to June 1951 . . . no Ductile Iron grates needed replacements although 150 gray iron grates had to be replaced after 6 weeks' service.

The sinter-plant foreman stated, "*The Ductile Iron grates still seem to be as good as new.*" Cast by Lakeside Foundry, Ltd., of Port Colborne, these Ductile Iron grates also out-performed steel grates tested previously.

ANOTHER EXAMPLE: The forging furnaces of a leading steel plant now have Ductile Iron doors supplied by United Engineering and Foundry Company, Pittsburgh 22, Pa. Gray cast iron doors which were subjected to 24 hours' continuous service daily, heat-cracked after an average life of about four weeks. A trial lot of annealed Ductile Iron doors lasted 17 weeks . . . or more than four times as long as those of gray cast iron.

APPLICATIONS: As cast, as well as heat-treated Ductile Iron parts . . . serving at elevated temperatures in scores of machinery, engine and furnace applications . . . provide a growth-resistance heretofore unavailable in gray cast iron.

AVAILABILITY: Send us details of your prospective uses, so that we may offer a list of sources from some 100 authorized foundries now producing Ductile Iron under patent licenses. Request a list of available publications on Ductile Iron . . . mail the coupon now.

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DUCTILE IRON

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THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

there's a "right" tool for every job

and

a "right" fastener...

You wouldn't intentionally slow down your production lines with inefficient tools or use the wrong machine for the job at hand. Isn't it equally logical to make sure that every fastening job is done with a fastener that is "just right"?

Differences in hardness and thickness of the tapped material require selection of the right type of tapping screw thread. This, in turn, works best with selection of the right hole size.

Lamson fastener engineers can advise you how to reduce the variety of fasteners and sizes at each assembly station, cut costs and improve assembly. Lamson control of quality and Lamson design produce low drive torques—high strip torques. Solve your fastening problems with Lamson Tapping Screws.

...specify Lamson tapping screws

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MACHINE SCREWS
Precision made for fast economical assembly.

SEMS
Pre-assembled lockwashers on tapping and machine screws.

TAPPING SCREWS
Choice of round, pan, truss, flat oval, hexagon and Phillips heads.

CAP SCREWS
"1035" Hi-Tensile Heat-treated steel.

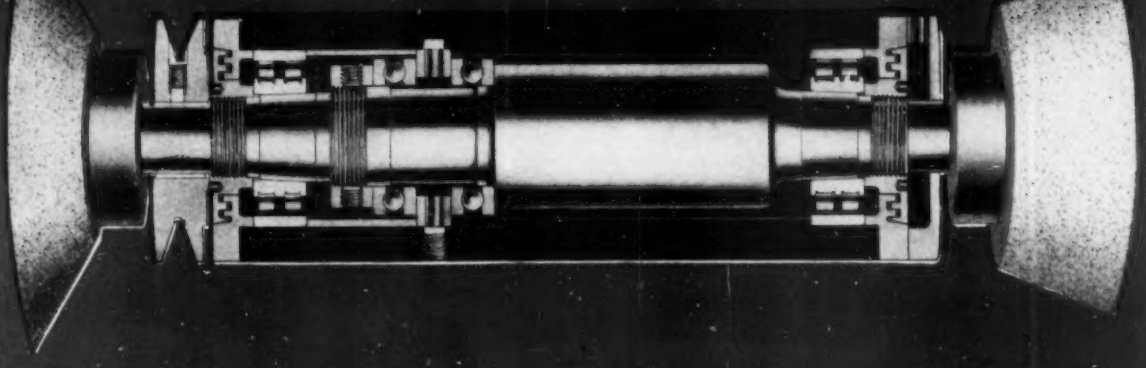
SQUARE AND HEX MACHINE SCREW NUTS
Semi-finished, hot pressed, cold punched.

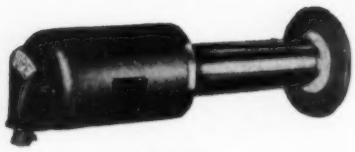
LOCK NUTS
Economical, vibration proof. Can be used repeatedly.

COTTER PINS
Steel, brass, aluminum and stainless steel.

"1035" SET SCREWS
Cup point type, hardened and heat-treated.

IT'S THE SPINDLE THAT DOES THE WORK





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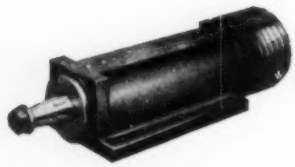


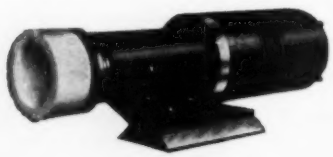
P-666

Specify POPE Precision Grinding Spindles and be certain of continuous production of finely finished parts.

Look at the pair of thrust bearings. They eliminate any endwise movement of the shaft in either direction.

Look at the double row cylindrical roller bearings. They have the rigidity to properly support the wheel for removing metal faster while producing fine surface finishes.

Lubrication — POPE System — requires no attention for the life of the bearings.



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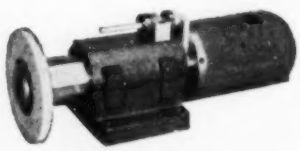

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P-2500

No. 91

Specify **POPE** PRECISION SPINDLES

POPE MACHINERY CORPORATION

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General Electric rubber-jacketed cords, designed for today's appliances, are built to take day-to-day abuse. One example is G-E Type SV cord . . . a lightweight, flexible cord particularly designed for use on vacuum cleaners, food mixers, office machines, and similar light-duty equipment. The complete line of G-E Types S, SO, and SV cords will provide you with a dependable, flexible cord for practically any type of light-, medium-, or heavy-duty electrical appliance or industrial equipment. G-E cords are available in several types of conductors and in a wide variety of wire sizes.

On your assembly line

The tinned-copper conductors of most sizes and types facilitate connections and reduce assembly cost by eliminating the necessity for a cotton separator. The rubber insulation strips cleanly. You'll get economical assembly when you equip your products with G-E rubber-jacketed cords. For more information, write Section W60-367, Construction Materials Division, General Electric Company, Bridgeport 2, Connecticut.

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You can put your confidence in—

GENERAL ELECTRIC

WIRE AND CABLE IDEAS for Product Designers

Magnet Wire: For Class H applications (for 180 C and even higher temperatures) G-E Deltabeston* is supplied with silicone-varnish impregnation. This applies to Deltabeston magnet wire insulated with either glass or asbestos.

Handy Booklet: 24-page booklet for product designers. Contains charts, specifications, applications for the standard line of G-E wires, cables, and cords. For daily reference. Write for your copy.

Special Applications: Call on G.E. when your application requires a special cable construction. We have assisted many designers in the past. We want to help you.

Flamenol: General Electric's Flamenol* wire has long-lasting, thermoplastic insulation. Flamenol wire is almost completely resistant to oils, acids, alkalies, moisture, ozone, and sunlight — will not support combustion. Where long life is important and space is limited, G-E Flamenol wire may be your answer.

ALLIS-CHALMERS

PUMPS for Designers

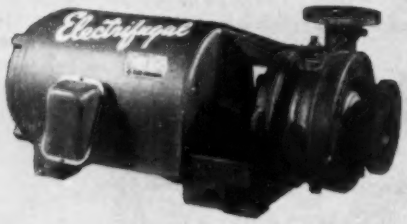
Easy-to-Install pumps

Fit Most Designers' Needs

FHP pump

Up to 80 gpm, heads to 125 feet.

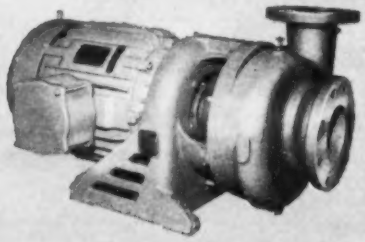
Compact pump and motor requires only two bolts for installation. Rigid construction holds alignment for longer bearing and seal life. Mechanical seal. Open impeller economy model does adequate job on many installations at very low cost. Closed impeller model for higher heads. Also available as frame-type pump for separate mounting.



Electrifugal pump

Up to 500 gpm, heads to 220 feet.

Only pump with unit-cast frame. Motor and pump are mounted on a single shaft in a one-piece rigid cast-iron frame. Alignment is rigidly held but there is plenty of space for maintenance. Installation requires only four bolts. Standard packing or mechanical seal available. Also built as frame-type pump for separate mounting.



Supporting adapter pump

Up to 2500 gpm, heads to 550 feet.

Flange motor and pump mounted on sturdy cast-iron supporting adapter. Motor and pump use same shaft. Rigidity assures vibrationless operation and long bearing life. Only four bolts required for installation. Available with standard packing or mechanical seal. Built in same ratings as frame-type pump for separate mounting.

FREE ENGINEERING HELP

YOUR ALLIS-CHALMERS PUMP REPRESENTATIVE is thoroughly familiar with the pump problems of equipment designers. He can offer you valuable time and money-saving suggestions in planning your equipment.

When you need help on a pump problem, call your nearby Allis-Chalmers District Office. Write Allis-Chalmers, Milwaukee 1, Wisconsin for Bulletins 52B7529, 52B6140 and 52B6083 describing these designers' pumps.

A-3969

Electrifugal is an Allis-Chalmers trademark.

ALLIS-CHALMERS

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Most Modern Die Casting Equipment

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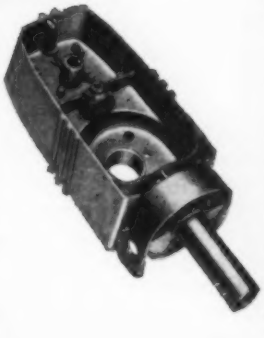

. . . produced under controlled process technique that insures quality.

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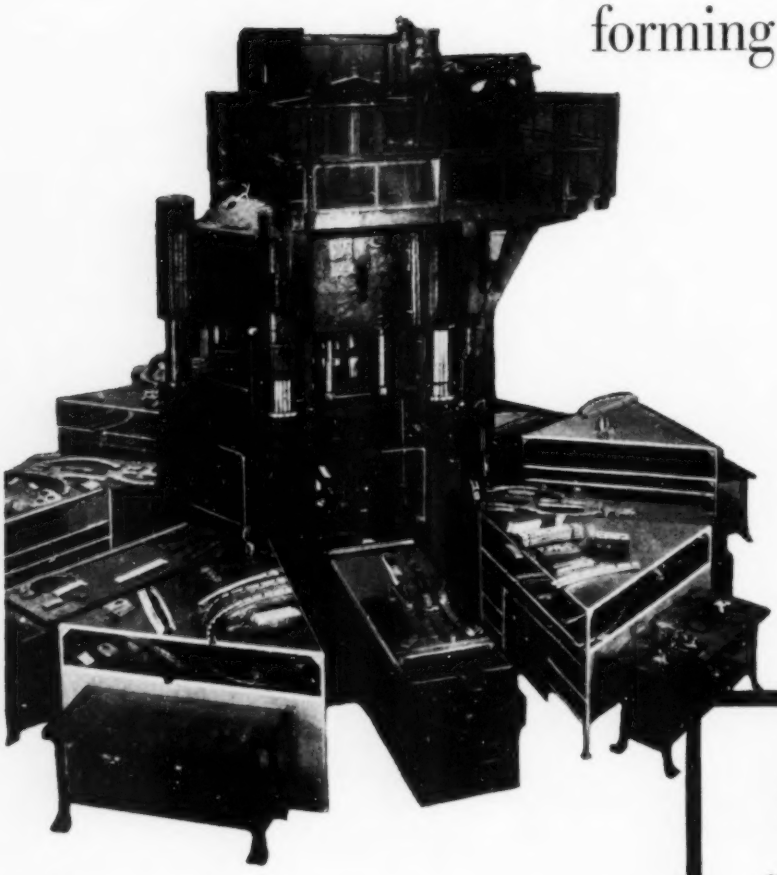
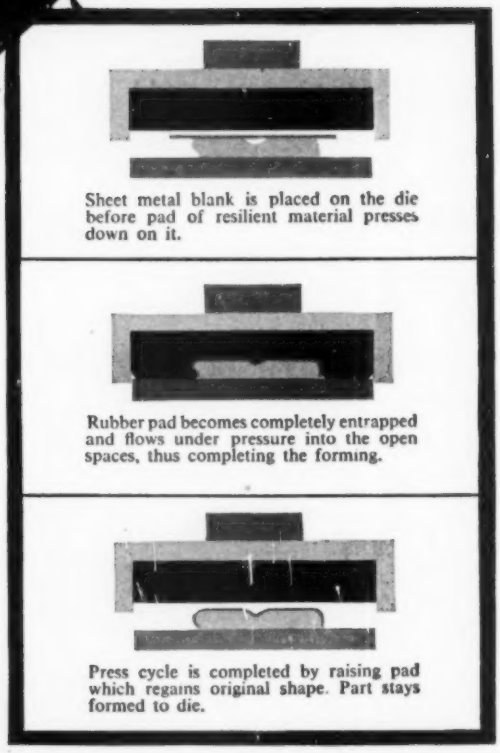
How does U. S. Rubber help speed up the forming of sheet metal?



THIS six-sided hydro-press used in the Guerin Process is equipped with male dies—with U.S. Rubber's resilient HOMOGENEOUS press forming pads utilized as female dies. The press forms a sheet of metal into various designed metal pieces by pressing it between the homogeneous rubber pad and the forming dies.

United States Rubber Company engineers developed this homogeneous pad to meet every exacting specification of the aircraft manufacturer. It makes possible better formed parts—by providing pressure throughout so that every part of metal is subject to proper forming pressure. The laminated pads originally used did not last long, due to ply-separation, and failed to provide uniform pressure.

Like many another manufacturer, the maker of this hydro-press has found that "U.S." engineers tackle industrial problems and lick them. Maybe they can help you. Write to address below.



Sheet metal blank is placed on the die before pad of resilient material presses down on it.

Rubber pad becomes completely entrapped and flows under pressure into the open spaces, thus completing the forming.

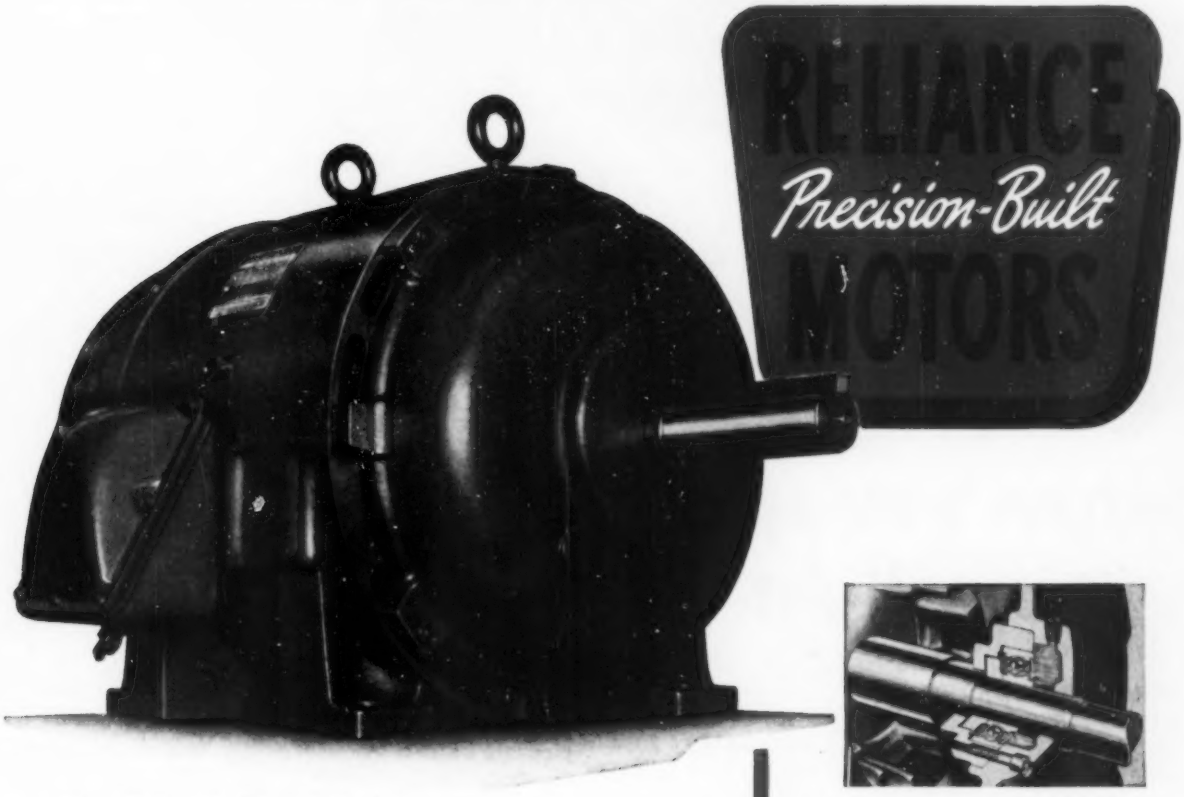
Press cycle is completed by raising pad which regains original shape. Part stays formed to die.

Product of U.S.RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

DEPENDABLE...because they're ENGINEERED FOR RUGGED SERVICE



Reliance Totally-enclosed Fan-cooled A-c. Motor. All other standard enclosures available, with wide choice of mechanical designs and special mountings. Ratings from ¾ to 300 hp.

Rugged Reliance A-c. Motors are proving that "All Motors Are NOT Alike" on grueling jobs in every industry. Heavy shafts, bearing to bearing—indestructible pressure-cast aluminum rotors—shock-resistant frame and bearing-bracket construction—man-sized conduit boxes—pressure-welded core laminations—and tough Reli-X insulation are among the many features that make these motors the most dependable, most economical that you can buy.

To see for yourself why these better motors will perform better on *your* job, call an Application Engineer at the Reliance Sales Office nearest you. B-1452

WHY THE RELIANCE PRE-LUBRICATED BEARING DESIGN IS BEST

The Reliance pre-lubricated bearing provides *four times more operating hours without re-lubrication* than any other bearing used in motors today. And—whatever your lubrication schedule—*you just can't grease 'em wrong!* To get the complete "inside story" on motor bearings, write today for Bulletin B-2201. It contains hard facts on the advantages of the Reliance pre-lubricated bearing design, with cutaway view, cross-section diagram, comparison chart, and statements by bearing manufacturers.

RELIANCE ELECTRIC AND ENGINEERING CO.

1060 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*

when you specify light wall schedule 5 pipe

WHAT SCHEDULE 5 PIPE IS—
A light wall pipe, Carpenter Schedule 5 gives you more feet of pipe for every pound of scarce stainless steel. So you can quickly see how Schedule 5 reduces your cost per foot. Plus the fact that the larger I.D. means increased flow area.

HOW SCHEDULE 5 REDUCES COSTS
First saving is 40% to 50% on the cost of your pipe.

Since Schedule 5 is considerably lighter, this means quicker and easier installation.

And, because the increased capacity of Schedule 5 lets you use the next smaller pipe size, you can reduce substantially your costs of valves, fittings, etc.

FITTINGS ARE AVAILABLE
This pipe is easily adapted to use with existing lines of tubing or Schedule 40 and 10 pipe, using simple connectors. Fittings as well as stocks of Schedule 5 pipe are carried by conveniently located Carpenter distributors.

ADDITIONAL ADVANTAGES

Tubing sizes can now be replaced with light wall *pipe* . . . for ready hook-up with standard valves, pumps and other equipment which is normally manufactured in pipe sizes.

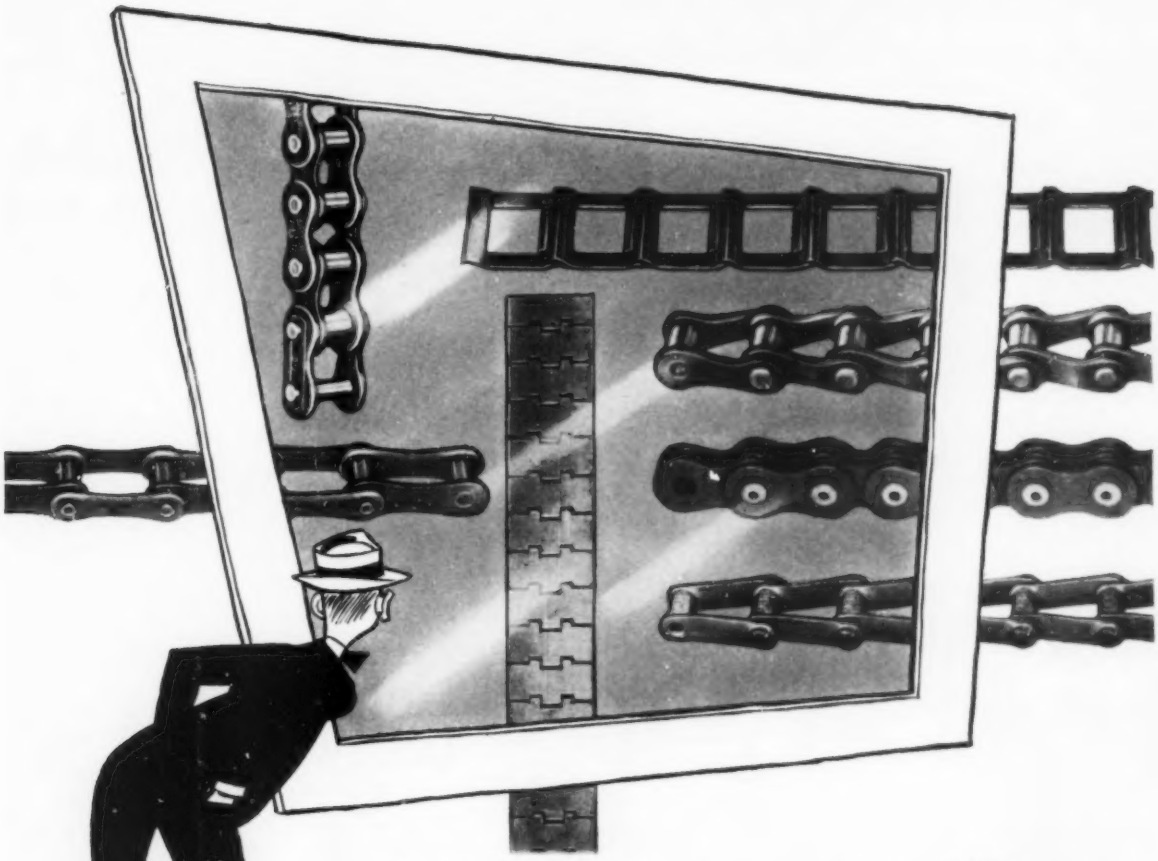
Data Sheets give you complete information about Carpenter Schedule 5 Stainless Pipe. Write for your personal copy. THE CARPENTER STEEL COMPANY, Alloy Tube Division, Union, N. J.
Export Dept.: The Carpenter Steel Co., Port Washington, N.Y. "CARSTEELCO"

Carpenter

THE U.S. NEEDS YOUR STEEL SCRAP NOW

STAINLESS TUBING & PIPE

- guaranteed on every shipment



window shopping costs nothing...
can save you plenty

It pays to "shop around" before you make your power transmission or conveyor chain selections. Because, in order to get the most for your money, you need the right chain for your designs. For example, a precision-finished roller chain is ideal for high speed drives. But, roller chain is not the economical, efficient choice for slow speed, heavy-duty service. A heavy-duty steel or cast chain may be your answer here. That's why it will pay you to "shop" through the *complete* Chain Belt line before you make your choice. There's a size and type to fit any power transmission or conveyor need.

Don't be handicapped by relying on a supplier with a limited line to answer all your needs. It may cost you more... may handicap the expected performance of your machines.

Your Chain Belt Field Sales engineer will be happy to assist you in making the exact chain selection that best fits your requirements. He is not prejudiced by the limitations inherent in an incomplete chain line... can recommend the chain that will give you the service you want... at the lowest possible cost. For complete information or engineering assistance, mail the coupon.

REX
BALDWIN-REX®

Chain Belt COMPANY OF MILWAUKEE

Atlanta • Baltimore • Birmingham • Boston • Buffalo • Chicago
Cincinnati • Cleveland • Dallas • Denver • Detroit • El Paso • Houston
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Salt Lake City • San Francisco • Seattle • Tulsa • Worcester

Distributors located in principal cities in the United States and throughout the world
EXPORT OFFICES: Milwaukee and 19 Rector Street, New York City.

CHAIN BELT COMPANY 53-503
4715 W. Greenfield Ave., Milwaukee 1, Wis.

Gentlemen:
Please send me information on Rex and Baldwin-Rex chains
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☐ Slide rule drive selector for slow to medium speeds

Name.....

Company.....*Dept.*.....

Address.....

City.....*State*.....

STEEL WOOL bursts into flame under a jet of fluorine gas in an experiment at The Whitemarsh Research Laboratory of The Pennsylvania Salt Manufacturing Company.

When Metal Bursts into Flame

Imagine, if you can, an element so fierce it burns up steel. One that claws its way through fire-brick . . . makes water burn like alcohol . . . destroys almost everything it touches.

That's fluorine for you!

And for over two hundred years chemists racked their brains to find some material that would hold fluorine. Hold it for even a few minutes' study.

Numerous materials – all considered dependably resistant to corrosion – were tried. Most went up in a flash.

Some few seemed to work, momentarily. But let temperature rise a trifle, or pressure build up . . . or a trace of moisture seep in . . . then dig out the wreckage and start over.

Finally Nickel and its alloys were tried. They work. They last for months where other materials failed in days or weeks.

Today, you find Nickel and Inco Nickel Alloys in equipment that produces fluorine . . . in pumps and piping and valves where fluorine is compressed, stored, and processed. Nickel and Inco Nickel Alloys hold fluorine, even under heat and pressure. By the way, if you would like to know more about fluorine, ask us for a copy of "Fluorine Makes Its Debut."

When you have a metal problem

If it's corrosion, it can't be any tougher than that caused by fluorine . . . and the solution may be found in Inco Nickel or one of the Inco Nickel Alloys.

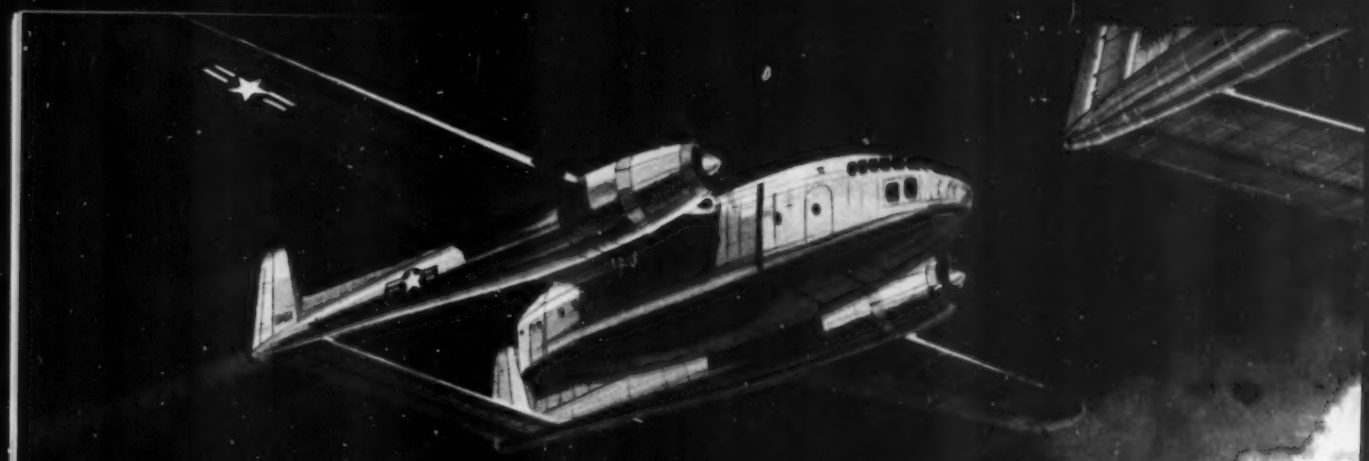
Inco corrosion engineers are ready to help you. They've prepared a Corrosion Data Work Sheet to make it easy for you to outline your problem to them. Write for it, without obligation, of course.

• • •

Or perhaps your metal problem concerns temperatures—high or low . . . stresses or fatigue resistance. Whatever it may be, Inco engineers will gladly help you find the answer. The International Nickel Company, Inc., 67 Wall St., New York 5, N. Y.

Inco Nickel Alloys

Monel® • "R"® Monel • "K"® Monel "KR"® Monel • "S"® Monel • Nickel Low Carbon Nickel • Duranickel® • Inconel® Inconel "X"® • Incoloy® • Nimonics®



UNSEEN HANDS ABOARD THE FAIRCHILD C-119

From nose to tail, the famous Fairchild "Flying Boxcar" is manned by unseen hands—4 different types of Lear Products, performing a dozen different tasks. Included are such precision-engineered electro-mechanical products as Linear and Rotary Actuators, Flexible Shafting and Screw Jacks.

Operating cowl flaps, trim tabs, air exit flap, main gear up-lock, paratainer door—helping regulate and control the flow of air to engine, cockpit, and cargo—performing many other exacting and varied tasks, Lear electro-mechanical components and systems are making essential contributions to the vital service rendered by the C-119.

In the field of electro-mechanical actuation and controls, twenty-one years of engineering development, design, and precision manufacturing have earned for Lear a position of recognized leadership in flight control.

Advancing the Frontiers of Flight

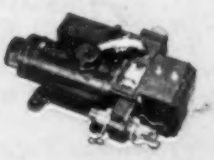
GRAND RAPIDS *Division*

110 Ionia Ave. N.W., Grand Rapids 2, Michigan

Lear-Romec Division, Elyria, Ohio
LearCal Division, Los Angeles, California
Lear, Incorporated, Grand Rapids 2, Michigan

LEAR LINEAR ACTUATOR Series 401—precision engineered, installed in military and commercial aircraft, is typical of the Lear electro-mechanical actuators designed to meet the exacting requirements of the C-119.

ROTARY ACTUATORS



POWER UNITS

ELECTRIC MOTORS

SCREW JACKS

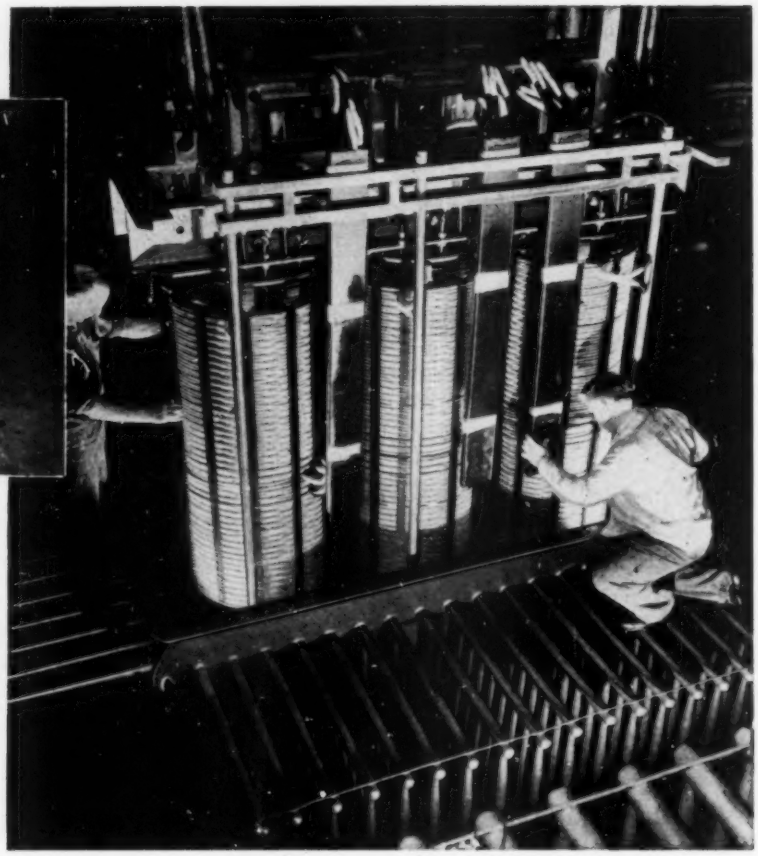
OTHER ELECTRO-MECHANICAL EQUIPMENT:

Electronic Temperature and Positioning Controls • Magnetic Clutches • Sub-Miniature Motor Generators • Motor-Driven Precision Gear Mechanisms • Servo Motors

Another new development using

B. F. Goodrich Chemical *raw materials*

Typical use of Hycar nitrile rubber for small-sized gasket—on Spirakore Distribution Transformer.



GIVES SEALS "9 LIVES"!

Photos courtesy of General Electric Company, Schenectady, New York. B. F. Goodrich Chemical Company supplies the Hycar rubber only.

Transformer gasket made of Hycar boasts many improvements

GASKETS for sealing giant transformers like the one pictured used to cause many problems. Leakage was the worst. If liquid leaked out, or water or moist air leaked in, operating efficiency dropped and service and maintenance costs went up.

But when Hycar nitrile rubber was tried, engineers found in it the nine important gasket material advantages they'd been looking for.

See what Hycar nitrile rubber does!

It resists attack by hot insulating oil or Askarel

Will not swell in contact with hot insulating oil

Does not contaminate insulating oils

Resists permanent deformation under compression

Ages well

Has low permeability to water vapor

Is reasonable in cost

Seals without use of adhesives

Has excellent physical properties for assembling

Hycar nitrile rubber compounds have helped solve many difficult problems—have helped improve and develop many saleable products. Perhaps Hycar is just what you're looking for. Helpful information for the asking—just write Department HT-2, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

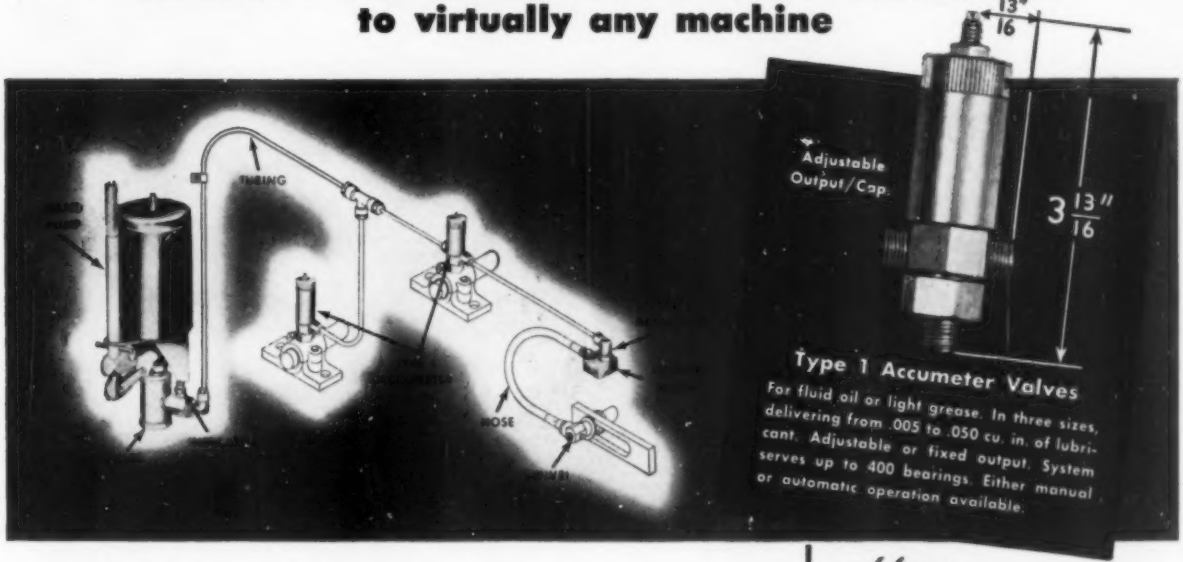
Hycar
Reg. U. S. Pat. Off.
American Rubber

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON organic colors

Designed... **to eliminate hit-or-miss machine lubrication**

ALEMITE Accumeter® CENTRALIZED LUBRICATION

extends the protection of automatic lubrication to virtually any machine



Type 1 Accumeter Valves

For fluid oil or light grease. In three sizes, delivering from .005 to .050 cu. in. of lubricant. Adjustable or fixed output. System serves up to 400 bearings. Either manual or automatic operation available.

Centralized lubrication with Alemite Type I Accumeter can make your machines produce more, last longer, and cost less to run—*impressive savings at low cost!* This simple, single-line system is completely versatile—easy to design, easy to build into any machine because valves fit directly on bearings, replacing grease fittings, oil cups or reservoirs.

In seconds, in a fraction of the time required for hand lubrication, Alemite Accumeter Lubrication System delivers the exact, measured amount of clean oil or grease *from one central point* to all bearings of a machine. The machine keeps operating—no production time lost—no bearings are missed. No wonder 95% of big plants buying machine tools specify *centralized lubrication!*

Type 1 Accumeter Systems serve single machines or groups of machines with semi-automatic or fully automatic lubrication. It is just one of three types of Accumeter Systems made by Alemite to meet your exacting requirements.

offers...

ALL THESE ADVANTAGES!

- **Eliminates shutdown time for lubrication. Adds productive time to machine output.**
- **Seals completely against dirt, grit, water all the way from "Barrel-to-Bearing."**
- **Prevents bearing troubles due to neglect or use of wrong lubricant.**
- **Services *all* bearings—including those inaccessible or dangerous—in one operation.**
- **Avoids work spoilage and bearing repairs due to over-lubrication.**

FACTORY-TESTED . . . FIELD-PROVED

Proved in the field. Exhaustive tests showed *no variation* in the amount of lubricant discharged . . . even after 73,312 lubrication cycles, *equal to 122 years of twice-a-day service.*

ALEMITE
REG. U. S. PAT. OFF.

A PRODUCT OF SW STEWART WARNER

Free—Alemite Accumeter Catalogue and Engineering Data Book.

ALEMITE, DEPT. T-53
1850 Diversey Parkway, Chicago 14, Ill.

Please send me my free copy of the Alemite Accumeter Catalogue and Engineering Data Book.

Name _____

Company _____

City _____ State _____

They Haul Oil, Machinery and Ice Cream

Yet They have One Advantage in Common

It would be hard to select three vehicles that vary more in design and purpose than these. But dissimilar as they are, they all share one important feature—each is built with low-alloy, high-strength Mayari R.

There seems to be no limit on the types of trucks, trailers and other highway vehicles that can be built better with this versatile steel. In some instances vehicle designers are interested primarily in increasing strength; in some they are interested solely in reducing deadweight without sacrificing strength; in others they aim at a middle course by combining a moderate increase in strength with a corresponding reduction in deadweight. Engineers have their choice when they work with Mayari R.

Another thing that can be counted on with this steel is increased resistance to atmospheric corrosion. Mayari R will resist corrosion damage 5 to 6 times longer than plain carbon steel of equal gage. It will also retain paint up to 80 pct longer, depending upon the composition of the paint used.

Get more information on Mayari R. Take advantage of its properties to improve your present designs. Our Catalog 259 will explain Mayari R features and applications in detail.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BUY NO RUBBER PARTS

until you've investigated

G-E SILICONE RUBBER!

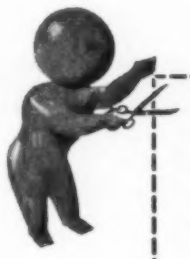
In the market for rubber parts? Then you'll want to investigate the amazing advantages of General Electric silicone rubber before you buy or specify. Designers find G-E silicone rubber solves problems where conventional rubber fails . . . that it does jobs *no other* rubber can do!

For example, G-E silicone rubber remains flexible from −100 to 500 F and has unusual resistance to weather and chemical attack. This means long-lasting rubber parts for applications heretofore impractical with ordinary elastomers. It means:

- **Increased safety factor**—vital to aircraft
- **Less replacement cost**
- **Less rubber parts inventory**
- **A minimum of customer complaints** due to failure of conventional rubber

And . . . G-E silicone rubber can add important "sales pluses" to your product lines!

Get more information! Why not send today for a free booklet, "Imagineering with Silicone Rubber"? It describes the amazing properties of this material and its applications. Find out how G-E silicone rubber—now three times stronger than early varieties and available in many new forms—is more useful than ever. Just mail the coupon.



G-E silicones fit in your future

GENERAL ELECTRIC

CLIP AND MAIL TODAY!

General Electric Company
Section 353-2B
Waterford, New York

Please send me, free, your new booklet "Imagineering with Silicone Rubber." I am interested in G-E silicone rubber for:

( ) Seals and gaskets
( ) Wire and cable insulation
( ) Tapes and cloths
( ) Sponged products
( ) Belting
( ) Boots, sleeves, bellows
( ) Hose and ducting

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Address_____

City_____ Zone___ State_____

If you make any parts like these....

- Piston Pins
- Pump Cylinders
- Axles (front and rear)
- Bearing (Races)
- Airbrake Parts
- Drag Links
- Table Rollers
- Exhaust Lines
- Drill Shanks
- Frame Spacers
- Grease Guns
- Armature Bodies
- Hydraulic Brake Lines
- Filler Tubes
- Hydraulic Hoist Cylinders
- Ignition Wire Tubes
- Radio Parts
- Bushings
- Jacks
- Gun Barrel Drills
- Axle Housings
- Propeller Shafts
- Bobbins
- Push Rods
- Rocker-Arm Shafts
- Hollow Spindles
- Shock-Absorber Casings
- Spring Bushings
- Ironer Rolls
- Tie Rods
- Drill Collars
- Torque Tubes
- Spool Holders
- Golf Shafts
- Transmission Parts
- Spindle Caps

you can make them

better, faster and at less cost

with SHELBY SEAMLESS STEEL TUBING

BECAUSE Shelby Seamless comes to you with the basic shape and hole already made you can eliminate or greatly reduce many time and labor-consuming operations connected with boring and machining. You also save the wear and tear on expensive tools, as well as the needless waste of steel.

Another important advantage in using Shelby Seamless Tubing is that its excellent machining characteristics and uniformity speed up production and improve the quality of your output. *You can turn out parts by the millions and the last part will be as metallurgically and dimensionally accurate as the first part produced.*

Shelby Seamless Steel Tubing is available in a complete range of sizes; in different wall thicknesses; various finishes and steel analyses. Our engineers will be glad to submit recommendations based on a study of your particular requirements.

All Shelby Seamless Tubing is pierced from solid billets of uniform steel. This is the one manufacturing method that assures absolute uniform wall strength.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S SHELBY SEAMLESS MECHANICAL TUBING

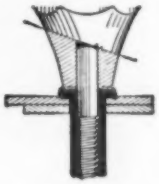
USS

UNITED STATES STEEL

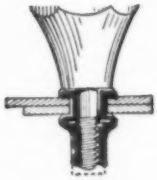
B. F. Goodrich RIVNUTS give new way to fasten leveling feet . . . cut costs!

Rivnuts provide at least 6 clean threads in one simple operation!

1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.



2 Rivnut is inserted—head firmly against work—tool at right angles to work.



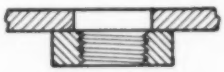
3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

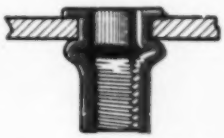
Compare these 4 methods of putting screw threads in thin sheet metal

Tapped—2 threads

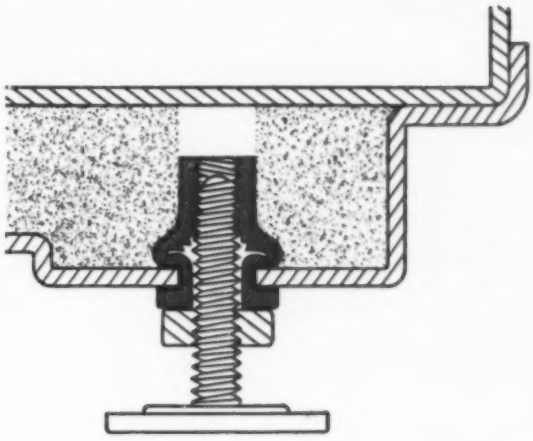
Pierced and tapped—3 threads



Projection welded—4 threads



Rivnut—at least 6 threads



APPLIANCE DESIGNERS were looking for a way to fasten leveling feet to the bottoms of refrigerators, stoves and automatic washers. The metal was too thin to tap, and welding would warp it. Besides, the threads would be ruined in the enameling process.

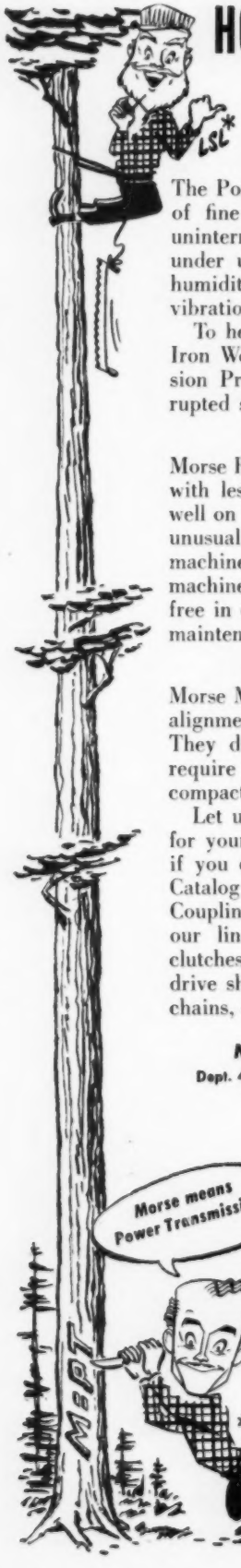
All these problems were solved by a B. F. Goodrich Rivnut—the *only* one-piece blind rivet with threads! Working from one side of the cabinet, one man installs the Rivnut in a few seconds. The easy-to-use power heading tool forms a bulge in the Rivnut shank—a "second head" that tightly grips the material. At least six threads remain clean to take the leveling-foot screw—more than enough to take the heavy loads. Installation is made *after* enameling without marring the finish.

Besides these advantages, the quick, simple installation of Rivnuts saves time, cuts assembly costs. For help on your fastening problem, write The B. F. Goodrich Company, Dept. PE-33, Akron, Ohio.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO *and* fasten WITH. Explains construction, gives proved applications . . . Write for your free copy today to the B. F. Goodrich Company, Department PE-33, Akron, Ohio.

B.F.Goodrich RIVNUT *The only one-piece blind rivet with threads*



HOW MORSE EQUIPMENT ADDS TO LONG LIFE OF SAWMILL MACHINERY, TOO

The Portland Iron Works manufactures a line of fine sawmill machinery noted for long, uninterrupted service life despite constant use under unfavorable working conditions—high humidity, dust- and grit-laden air, destructive vibration.

To help maintain that reputation, Portland Iron Works relies on Morse Power Transmission Products—also noted for long, uninterrupted service life.

Morse Roller Chains

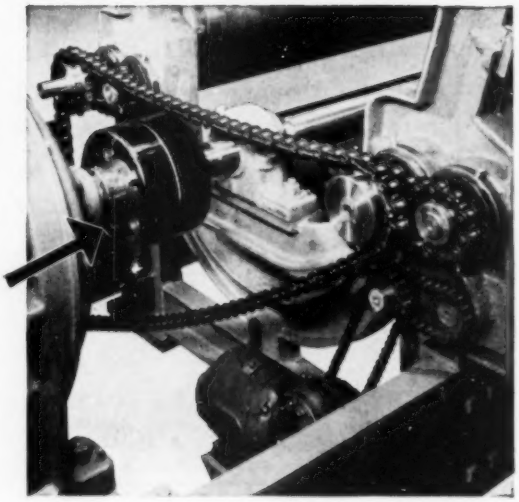
Morse Roller Chains transmit power positively with less than 1% friction loss, run equally well on long or short centers. They contribute unusual stamina and long service life to any machine on which they're used, outlive the machine in many instances. They are trouble-free in operation, help you reduce customers' maintenance costs.

Morse Morflex Couplings

Morse Morflex Couplings compensate for misalignment between driving and driven shafts. They dampen vibration, operate noiselessly, require no lubrication or adjustments. They're compact in relation to capacity.

Let us give you details on Morse Products for your power transmission applications. Or if you choose, write for Morse Roller Chain Catalog C51-50 or Morse Morflex Flexible Coupling Catalog C41-48. Other products in our line: overcenter clutches, multiple-disc clutches, roller- and silent-chain couplings, drive shafts, silent chains, double-pitch roller chains, cable chain, Hy-Vo Drives.

MORSE CHAIN COMPANY
Dept. 445 • 7601 Central Ave. • Detroit 10, Mich.



Above: Closeup of Morse Morflex Coupling (see arrow) and Morse Roller Chain Drives which contribute materially to long, trouble-free life of Portland Iron Works' Six-Inch Gang Edger shown below. Driven shaft on which 24" saws are mounted is connected to shaft of 30-60 hp. motor by Morse Morflex Coupling. Five Morse Roller Chain Drives are combined in separate power transmission system driving two infeeding and two outfeeding rolls which propel lumber.

* Long Service Life, Engineering Service Quality—which you get in unusual degree when you buy Morse Power Transmission Products.

MORSE
MECHANICAL
POWER TRANSMISSION
PRODUCTS

BW

Keynoter Series furniture designed by Edmond J. Spence for the Warren Furniture Manufacturing Co., Paterson, N. J.

Table-based utility cabinet has four drawers, each molded of black BAKELITE Phenolic Plastic, faced with "FORMICA," combining durability with good looks.

Utility cabinet features four drawers of black BAKELITE Phenolic Plastic to complement an adjacent door of wood. They are easily cleaned, strong, smooth-working.

Adjustable cocktail table with two drawers of BAKELITE Phenolic Plastic, in rich self-contained ebony finish. They contrast handsomely with the soft-grained wood.

ONE-PIECE MOLDED PLASTIC DRAWER KEYNOTES NEWEST FURNITURE DESIGN

Designers of contemporary furniture are looking to contemporary materials to express their ideas. Latest proof of their success is this drawer molded of BAKELITE Phenolic Plastics.

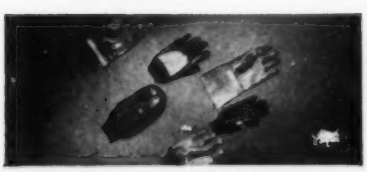
It has several advantages over conventional drawers—in design, manufacture, and use. With its rounded corners and absence of seams, it's easier to clean. Precisely molded, smooth, light in weight, it fits perfectly in place, slides open quietly and effortlessly. It withstands moisture and heat – won't swell, crack, or warp in normal use. Fast mass-production keeps its cost low.

The drawer illustrated is a rich ebony black that harmonizes with the modern woods—ash-blond korina, limed oak, dark mahogany. It could also be molded in other colors, such as red, brown and simulated wood-effects. The soft satin finish is acquired in the molding operation. The drawer can also be faced with wood or other materials.

BAKELITE Phenolic Plastics have properties that inspire fresh, new designs. They are readily applied to the production of large-size moldings, of which cabinets for air conditioning units and television sets are typical. You, too, can profit through the use of these materials. BAKELITE engineers can help you. Write Dept. PH-10.

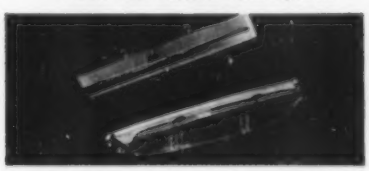
BAKELITE
TRADE-MARK
PHENOLIC PLASTICS

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corp.
UCC
30 East 42nd St., New York 17, N. Y.



Work Gloves coated with VINYLITE Brand Resins outlast other types 10 to 1. They withstand abrasion of wire, steel, concrete, blocks, wood. Resist chemicals, oil, water. Stay flexible, give sure grip. By Plasticote Glove Co., Milwaukee, Wis.

Housing and Shade for Klip-Lite that fastens where needed, are molded of BAKELITE Phenolic Plastic for light weight, ease of manufacture, good electrical properties. By Cable Electric Products Incorporated, Providence, R. I.



Door Shelves for Servel "Automatic Ice-Maker" refrigerator are made of BAKELITE C-11 Plastic, which provides strength, toughness, sharp detail, ease of cleaning, and resistance to food acids, oil, temperature extremes. Molded by Kusan, Inc., Nashville, Tenn.

See what adhesives are doing today!

Guarding Stratojet skin against bruising speeds

Raindrops can do a lot of damage—especially when you meet them head-on at the speed of sound. Dust particles can be equally harmful when they blast the leading edge of an airplane wing in high-speed flight.

Shielding airfoil surfaces against these conditions called for a specialized type of coating that would be super-tough, yet flexible enough to "roll with the punch" of rain and dust.

3M's solution to this problem was a rubberized plastic coating that could be sprayed on airfoil surfaces right on the production line. This coating provides a light-weight, long-lasting finish that guards Stratojet skin against bruising speeds!

See what adhesives can do for you . . .

Whatever your line of manufacturing, there's a 3M adhesive, sealer or coating made to fit your needs. Your 3M salesman would be glad to fill you in on the details. Call him or write directly to 3M, Dept. 43, 411 Piquette Avenue, Detroit 2, Michigan.

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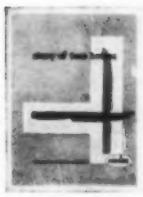

For additional information *and typical case histories, write for Bulletin. X-CREPE samples on request.*

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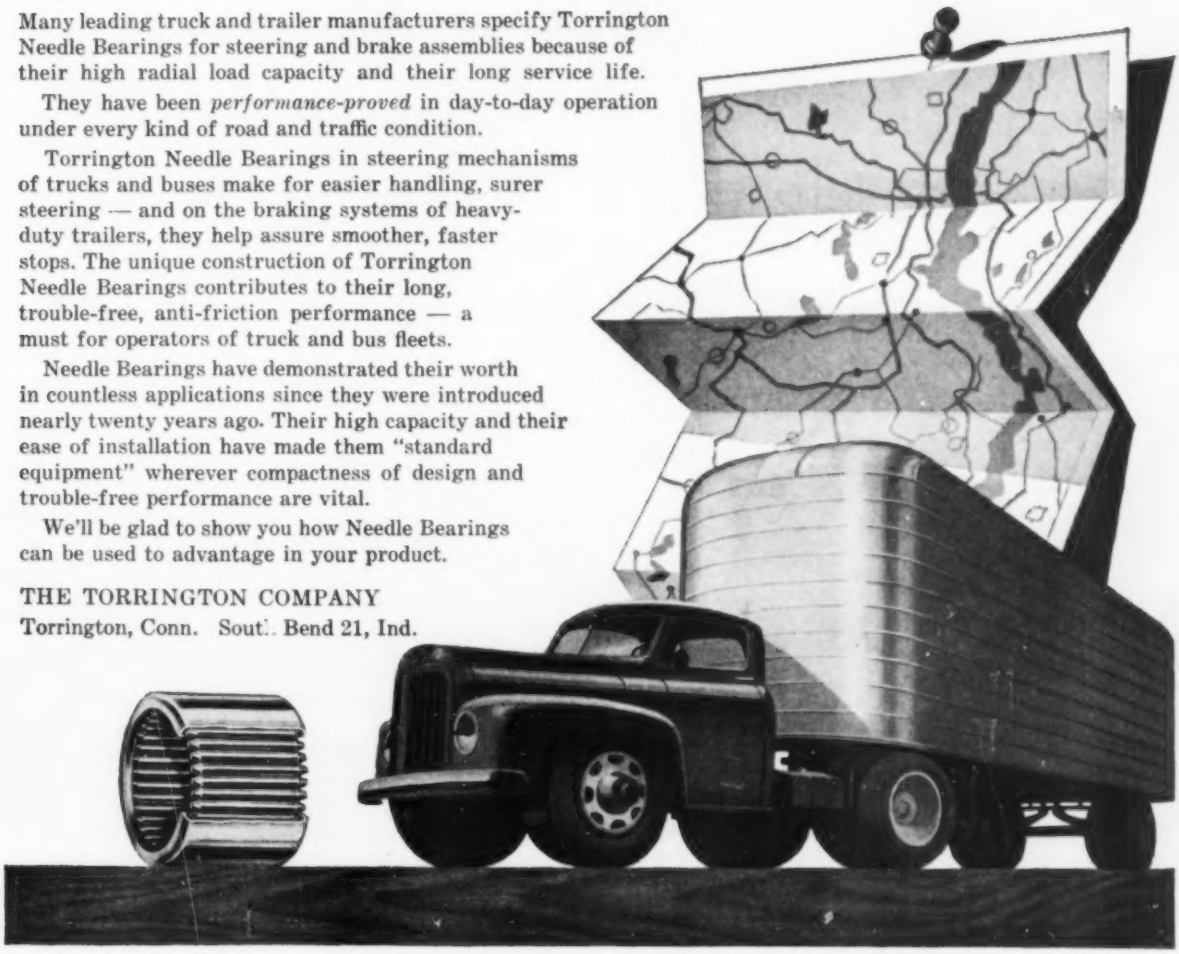
Torrington Needle Bearings in steering mechanisms of trucks and buses make for easier handling, surer steering — and on the braking systems of heavy-duty trailers, they help assure smoother, faster stops. The unique construction of Torrington Needle Bearings contributes to their long, trouble-free, anti-friction performance — a must for operators of truck and bus fleets.

Needle Bearings have demonstrated their worth in countless applications since they were introduced nearly twenty years ago. Their high capacity and their ease of installation have made them "standard equipment" wherever compactness of design and trouble-free performance are vital.

We'll be glad to show you how Needle Bearings can be used to advantage in your product.

THE TORRINGTON COMPANY
Torrington, Conn. South Bend 21, Ind.



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Trade-marks of some of the truck and trailer manufacturers whose products enjoy the benefits of Needle Bearings.

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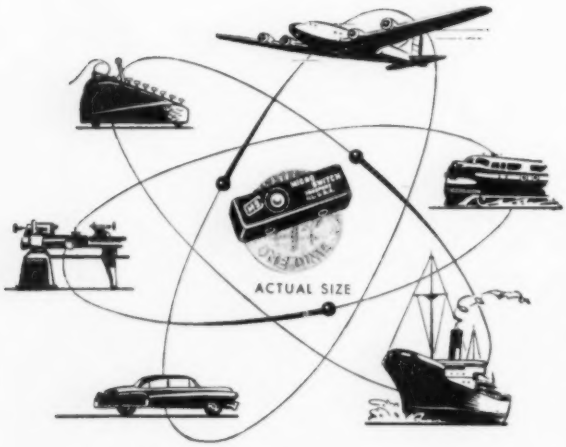
Better Products Thru Better Design

how highly precise, small size, lightweight MICRO Switches enable design engineers to achieve better design in a multitude of products



IT IS significant that more and more design engineers are accepting the fact that "the use of MICRO switches is a principle of good design."

In their constant striving to create "better products thru better design," it is quite natural and logical that they should utilize the application advantages of these versatile switches.

Being so highly precise, they are "naturals" when minute movement with very small actuating force is a "must." Being small in size, they fit into tight corners where more cumbersome components cannot be used. And being light in weight (some weigh only 1/15 of an ounce, and are about a dime's diameter in length), they are well-nigh perfect companions for magnesium and other weight-saving metals and alloys.

In addition, they can be supplied in over 6000 different combinations of housings, actuators and electrical characteristics. All this is indicative of the multitude of products in which they have influenced design procedures.

For instance:

* * * *

The remarkable growth of vending machines, from the penny gum dispenser to those which serve hot coffee with cream and sugar to taste, is an excellent example of the contribution of MICRO to better product design. Prior to MICRO'S developments, there were no components that were uniformly sensitive; that possessed sufficient electrical capacity; and that were properly protected against dust, moisture and other conditions, as well as protecting the owner. MICRO has contributed much to the design and development of coin-operated machines and has been an important factor in the growth of this important industry.

* * * *

The perfection of a device for counting paper money was a long, difficult and costly undertaking. Not until the precise operation, small movement differential and accurate repeat performance of MICRO switch were employed did the device prove dependable, for the use of MICRO switch made it possible always to detect the presence of more than a single bill as the paper money passed through the counter. MICRO'S development of a proper switch was the perfect solution. Successful use by many banks and financial institutions verifies the dependability of the device.

* * * *

Successful design of the popular garbage disposal unit, which shreds and carries off food waste at the turn of a faucet, hinged upon finding a switch of extremely small size, capable of operation in this unusual environment, and sensitive enough to operate by the low force of running water. The perfect answer lay in a MICRO switch which, when the water is turned on, closes the electrical circuit and starts the motor powering the shredding mechanism. The result—a better product through better design.

* * * *

So, time after time, not only in the design of new products but in the redesign of existing products, design engineers have proved and continue to prove that the "use of MICRO switches is a principle of better design."

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New *Vibrin X-1055B* cures at temperatures as low as 212°F—gives flexural strengths as high as 55-60,000 psi with glass fabric, 35-40,000 psi with low solubility polyester mat.

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This new resin has passed both the ASTM D-635 and Naugatuck's own far more stringent tests. With its low viscosity it's ideal for molding and impregnation operations.

3. Outstanding light stability! *Vibrin 117-LSC* gives transparent glass-reinforced sheeting *remarkable* resistance to ultra-violet light. Even after 400 hours in an Atlas twin-arc weatherometer, it *shows no color change!*

What's more, it has all the excellent handling characteristics of Vibrin 117 base resin.

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Sealing News & Tips

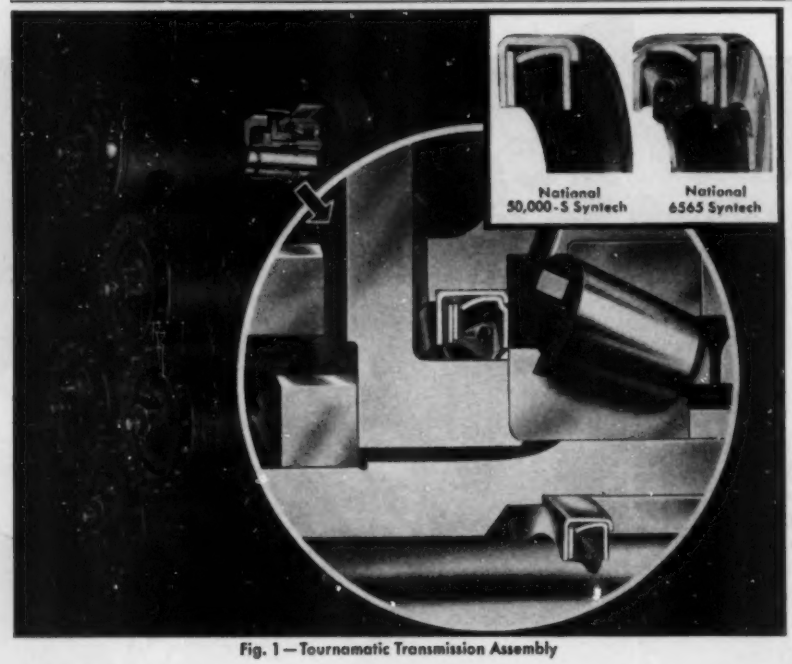


Fig. 1—Tournamatic Transmission Assembly

Concentrically-mounted National Oil Seals provide efficient sealing in Le Tourneau automatic clutch

The Le Tourneau Super C Tournadozer utilizes a constant-mesh, instant-shift transmission ruggedly designed with short, heavy shafts, helical-cut gears and anti-friction bearings. To protect gears and bearings and prevent lubricant leakage, ten National Oil Seals are installed in each transmission.

The transmission assembly (Figure 1) has five different shaft assemblies, and each utilizes two National seals mounted concentrically. The inner seal in each assembly is a standard-design National 50911-S Syntech* unit with a spring-tensioned synthetic rubber sealing member. It operates on an 870 r.p.m. (maximum) shaft hardened to 58-62 Rockwell and finished to ±0.0005. Its function is to protect the clutch from heavy gear oil.

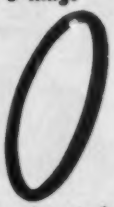
At the outer position, Le Tourneau uses a special National 6565 Syntech seal with a conventional spring-loaded main sealing member to retain bearing grease and a springless external lip to exclude dirt and water. This seal has a steel O.D. which fits into the retainer.

In solving these sealing problems, Le Tourneau and National Applications Engineers worked together, utilizing both standard-design and special National seals. In many cases, standard-design National seals solve problems quickly and economically; other applications may demand modifications to meet special conditions. In either event, National can offer you on-the-spot engineering help backed by 30 years of experience in solving sealing problems. Call the nearest National Applications Engineer for consultation.

Fig. 2—Super C Tournadozer

*Trade Mark Registered

New National O-Rings



National, a world leader in oil seals, now offers a complete line of O-Rings. National pioneered O-Rings two decades ago through a subsidiary organization. With O-Rings an integral part of the National line, you will get better engineering and sales service, consistent quality and uniformity, and the convenience of a common source for oil seals, O-Rings and shims.

New O-Ring Catalog

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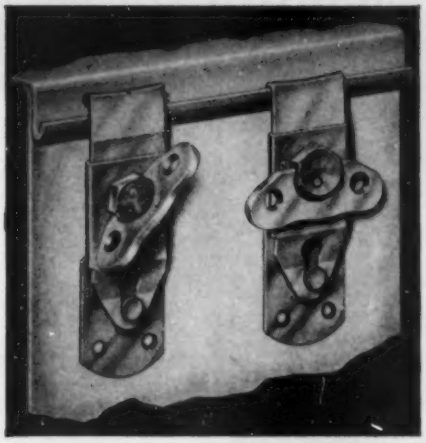
File: Simmons LINK-LOCK



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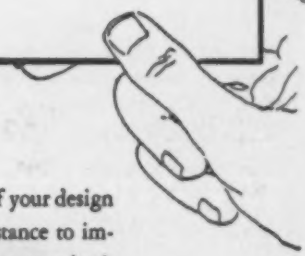

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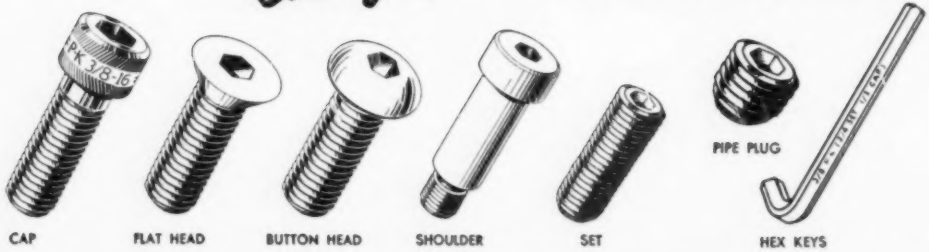

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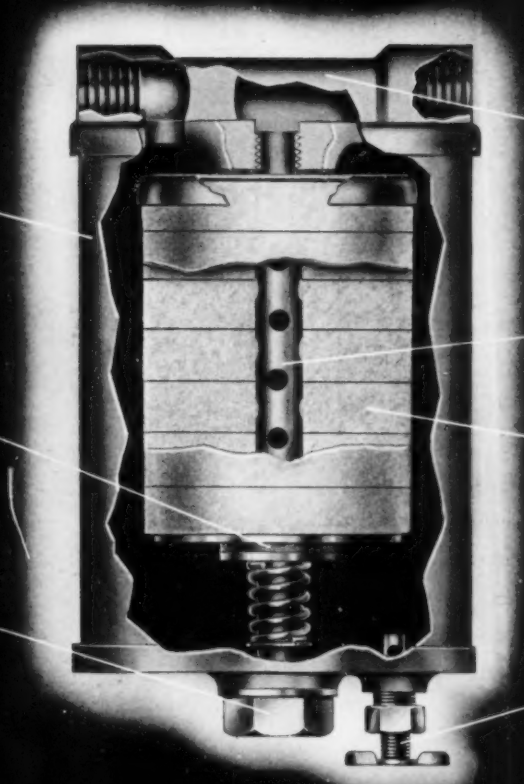

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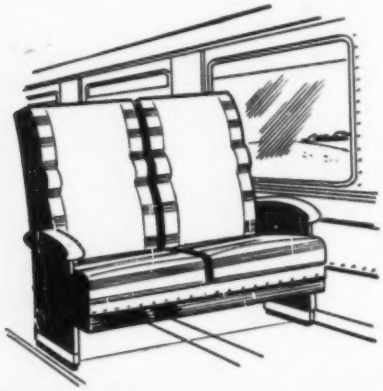
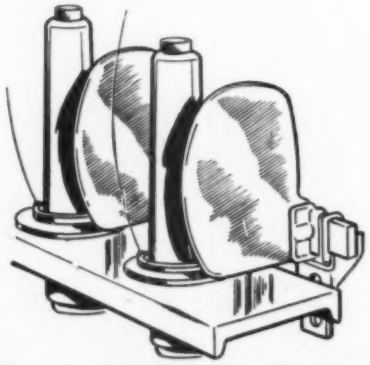
In testing laboratory or manufacturing plant, Hyatt's facilities are second to none. Continuing research in methods and materials, and exacting inspection with the finest in modern equipment, has made the Hyatt name a synonym for "highest quality." That's why Hyatt Roller Bearings are so widely used in design applications involving radial loads. Design engineers know that Hyatt bearings have been "performance-proved" for smoother, trouble-free operation and longer life. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

UNBRAKO BUTTON HEAD SOCKET SCREWS feature the following: threads to head; low head height; nonslip drive; hex socket that minimizes possibility of marred or mutilated heads; Class 3 fit; heat treated alloy steel; standard sizes from # 8 through 3/8" diameter.



USE UNBRAKO BUTTON HEAD SCREWS on transportation equipment—door and window frames, paneling, seats.



On textile machinery—slashers, twisters, bobbin shields.

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We suggest you do, because a standard UNBRAKO delivered from your distributor's stock means faster and better service. A standard will do the job as well as a special at much lower cost. For details about UNBRAKO Standards, write SPS, Jenkintown 28, Pa.

UNBRAKO® SOCKET SCREW DIVISION

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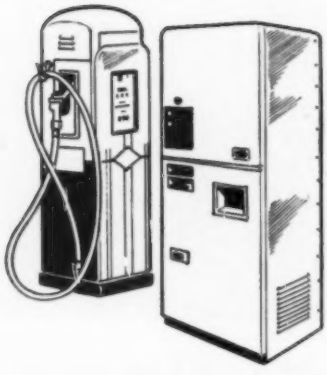
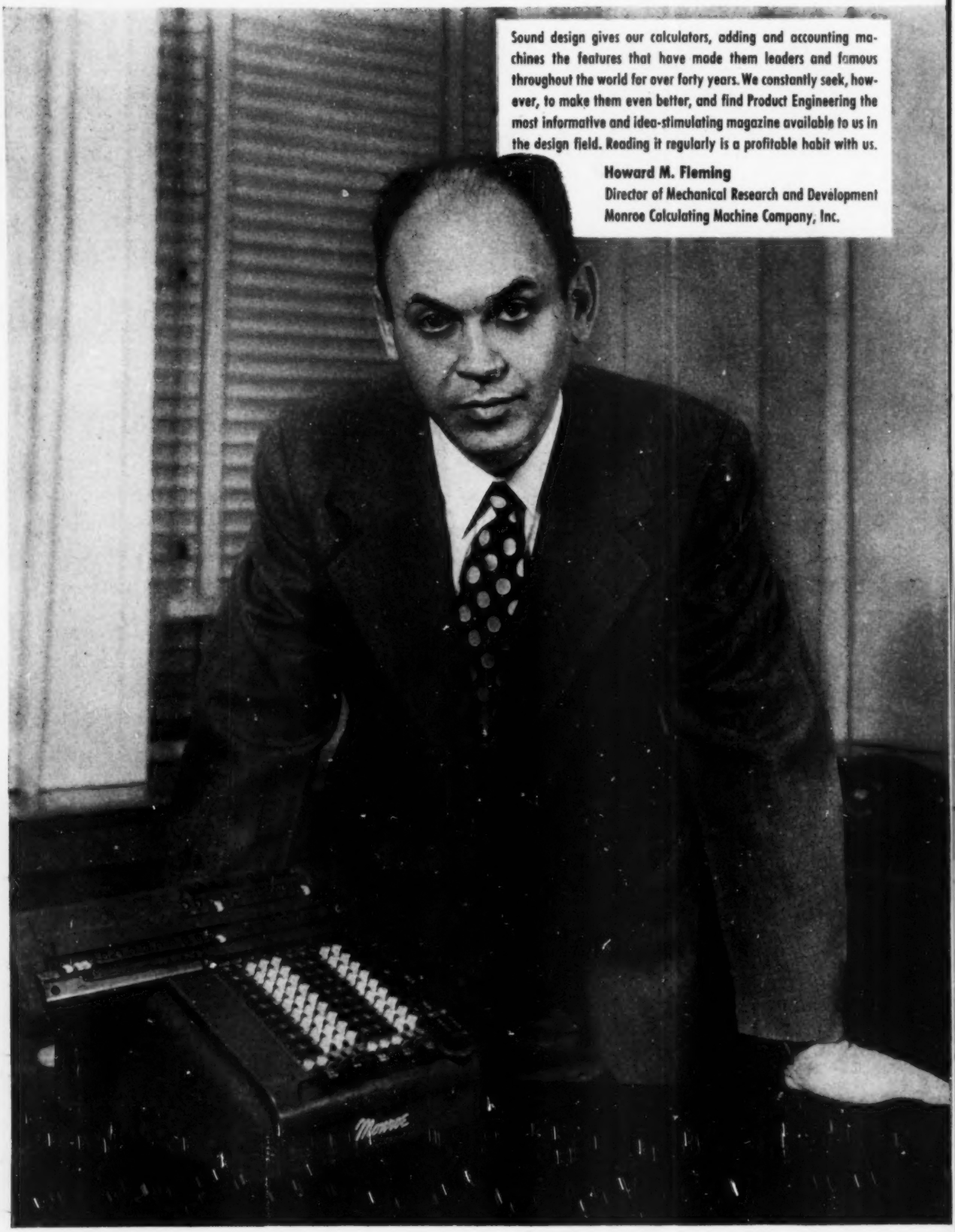


On sheet metal assemblies—coolers, gasoline pumps.

UNBRAKO Standards—as listed in the SPS Catalog—are stocked by leading industrial distributors everywhere.



Sound design gives our calculators, adding and accounting machines the features that have made them leaders and famous throughout the world for over forty years. We constantly seek, however, to make them even better, and find Product Engineering the most informative and idea-stimulating magazine available to us in the design field. Reading it regularly is a profitable habit with us.

Howard M. Fleming
Director of Mechanical Research and Development
Monroe Calculating Machine Company, Inc.

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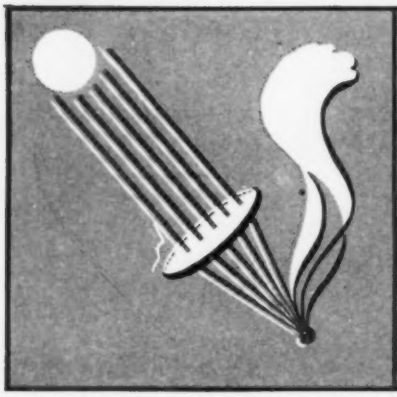
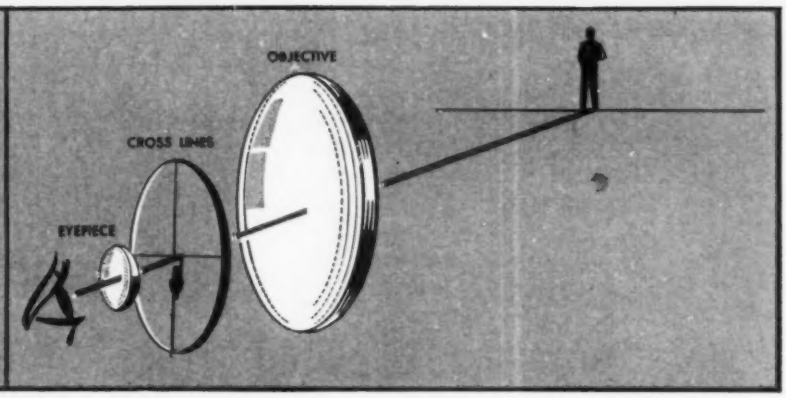
AMERICA'S NEW PRODUCTS READ PRODUCT ENGINEERING

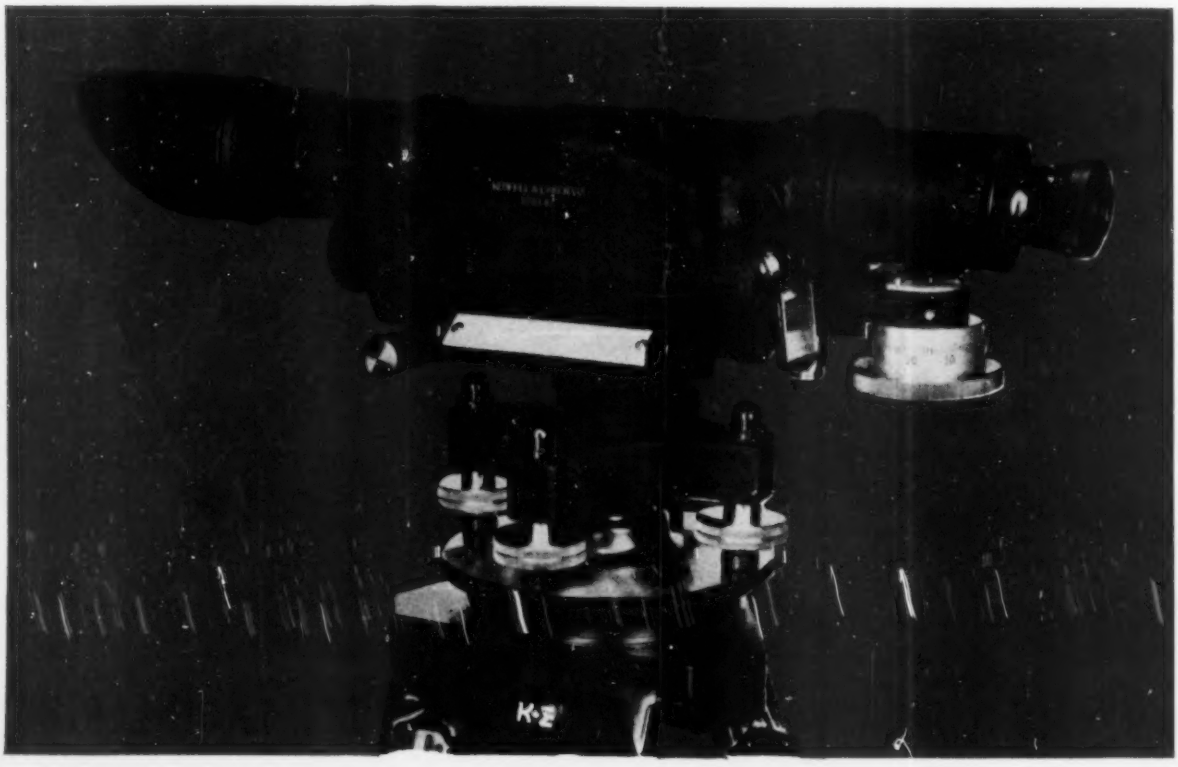
How the image you see gets PARAGON





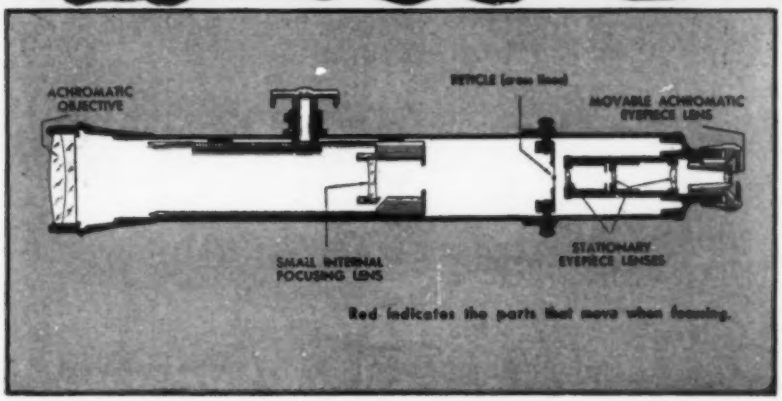
Even an ordinary reading glass can produce an image of sorts. That happens when the sun's rays are focused on a piece of paper as shown. All the rays passing through the lens concentrate at approximately one point where they form a small inverted picture or image of the sun.

By means of a lens, rays from any object at a distance can be made to concentrate inside a telescope in the same way. They form a tiny inverted picture of the object. If a screen like the ground glass of a camera were placed there and viewed through a magnifying glass, the actual picture of the distant object could be seen clearly. The lens that brings the tiny picture into a telescope is called the objective, and the small but powerful microscope that brings it out of the telescope into the eye is called the eyepiece.



into and out of a Telescope

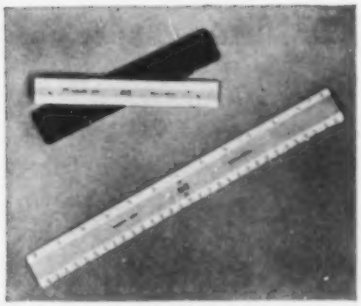
The Right Angle


ACHROMATIC OBJECTIVE
RETICLE (cross lines)
MOVABLE ACHROMATIC EYEPIECE LENS
SMALL INTERNAL FOCUSING LENS
STATIONARY EYEPIECE LENSES
Red indicates the parts that move when focusing.

Cross lines so fine as to be almost invisible can be placed inside the instrument at exactly the place where the miniature picture is formed. Then the eyepiece will greatly magnify not only the picture but the cross lines as well so that both are seen together. Basically, that is the principle of the telescopes used in K&E PARAGON surveying instruments and K&E optical tooling equipment. These contain additional refinements, such as a movable internal lens for focusing and extra lenses in the eyepiece that invert the picture a second time, so that the eye sees it right side up.

Naturally, the above description is extremely elementary. In fine telescopes, such as those made by K&E, every optical part must be made with surpassing accuracy so that the rays of light are not scattered. It is for this reason that K&E designs, grinds and polishes its lenses with an accuracy measured in millionths of an inch. The result is superior definition with unusual contrast and brightness. Minute detail can be clearly distinguished, and cross lines appear jet black.

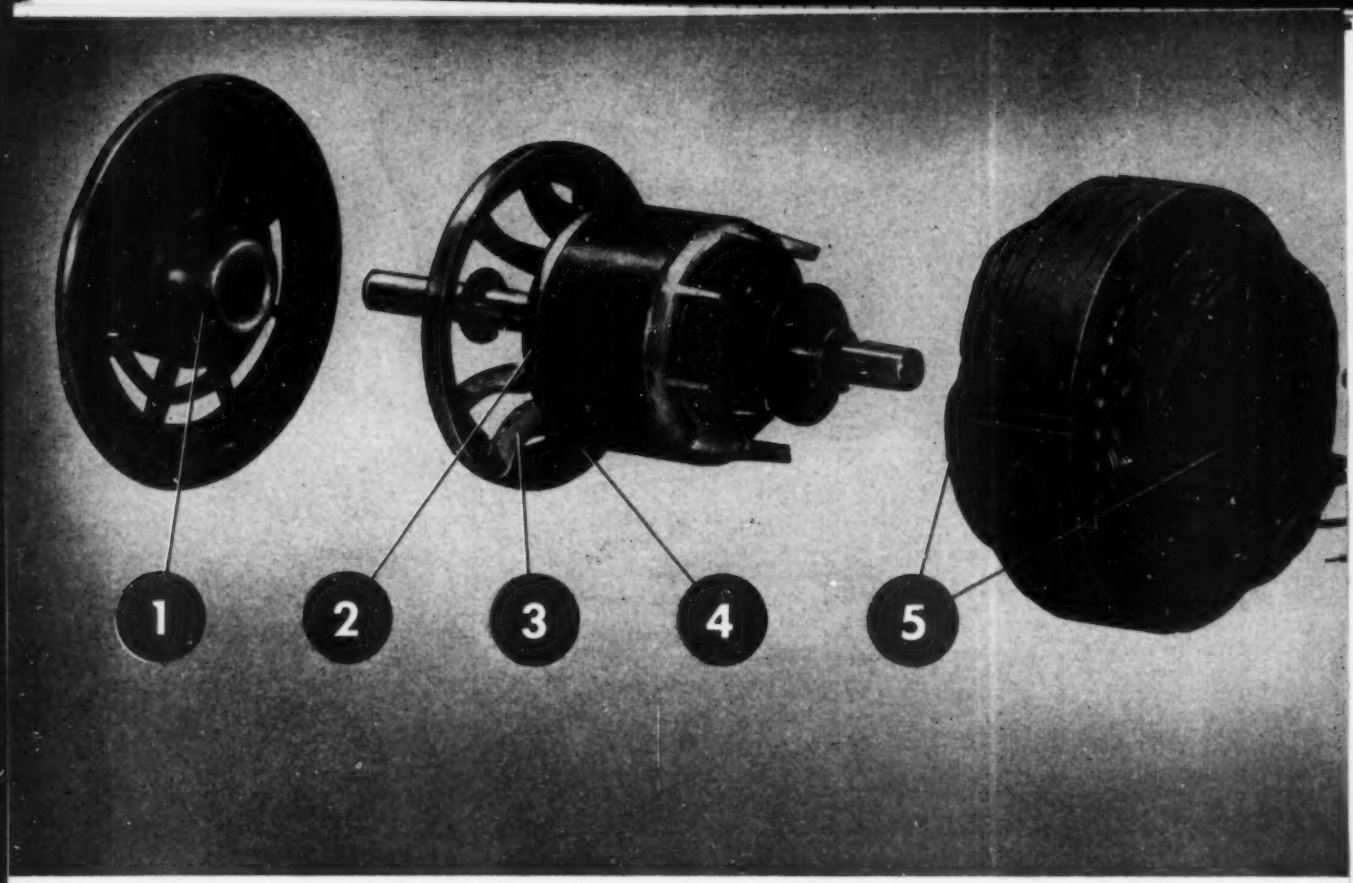
These are the exacting standards to which K&E builds instruments for engineers, surveyors and builders, as well as optical tooling equipment. The latter makes possible the application of surveying methods to manufacturing and construction problems involving high-precision positioning and alignment. Already these techniques have revolutionized tooling in the aircraft industry and are being adopted in other fields. Ask your K&E Distributor or Branch for details on what these superlative instruments can do for you.



Measuring scales are in constant use on every drawing board. For high quality and accuracy, use K&E PARAGON engine divided scales. They are made of the highest grade boxwood with scale faces of white plastic, permanently cemented. The graduations are filled with dense black pigment for high visibility against the white background.

There is a K&E graph sheet for almost every purpose. In a selection of 300 forms you can find graph sheets for plotting scientific data, forms for sketching and drawing, both mechanical and architectural, or for surveying and mapping. Also, business and financial forms of all types. All are on high quality drawing paper and on the finest tracing paper.

K+E KEUFFEL & ESSER CO.



1. VERSATILE!—All-angle bearing and lubrication system permits motor to operate in any position.

2. SMOOTH RUNNING!—Precise rotor balancing and concentricity of rabbets and bearings.

3. EFFICIENT!—New electrical design, ventilation give top performance in least space.

4. QUIET!—Advanced magnetic design and unitized rotor-fan casting provide quiet operation.

5. LONG-LIFE!—*ALL* synthetic insulation resists moisture, corrosion and electrical breakdown.

Ten good reasons for using

Above you see ten good, basic reasons for using the all-new G-E "form G" motor—right now! And at your right are four big "plus" reasons perhaps even more important to you.

Completely different . . . completely *functional* . . . this general-purpose motor gives you full NEMA performance plus up to *50% less weight, 40% less bulk—rating for rating!*

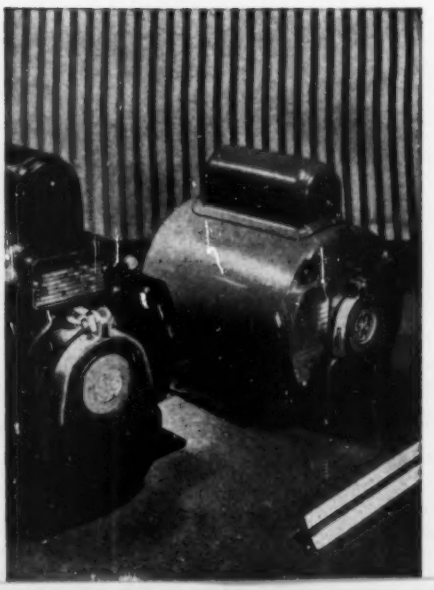
You get efficiency, sturdiness, extra long life . . . *plus quiet, all-angle operation in every rating!*

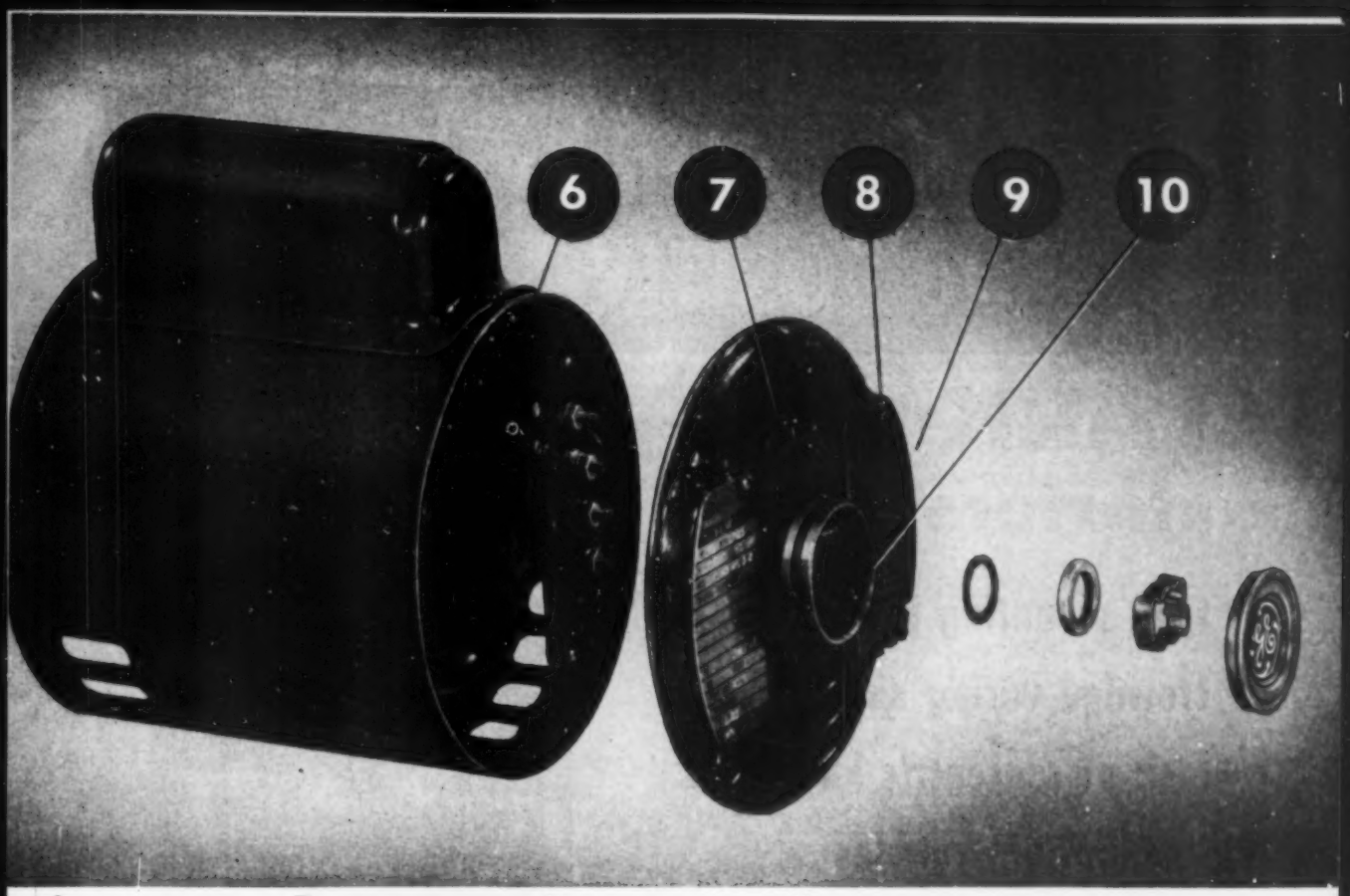
Now you can improve your product, speed assembly time, cut your handling and shipping costs.

Want more good reasons for using this new motor? Contact your nearest G-E Apparatus Sales Office or write for bulletin GEA-5567. Address Section 700-121, General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC

SMALLER . . .





6. STURDY!—Another G-E innovation: shell is expansion-fitted to stator: a strong *unit* assembly.

7. LESS MAINTENANCE! Spacious oil reservoirs—no lubrication required on some applications.

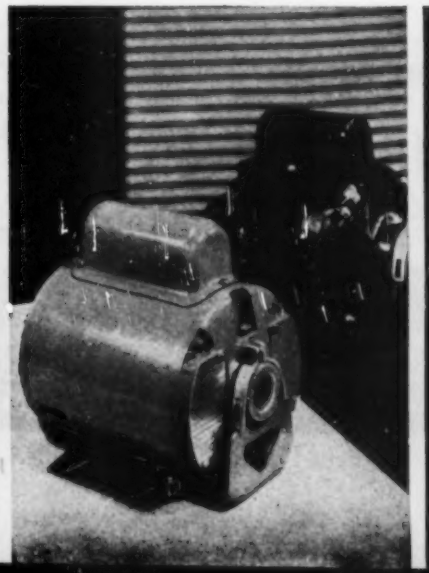
8. CONVENIENT!—Roomy terminal box—cover has connection and lubrication instructions.

9. RIGID!—This motor has strong, lightweight aluminum end shields especially rib-reinforced.

10. FLEXIBLE—Cradle bases—*solid* or resilient—facilitate easy mounting in any position.

the all-new G-E Fhp motor!

LIGHTER . . . ***BETTER LOOKING . . .*** ***MORE VERSATILE!***



A negative approach to POSITIVE BENEFITS

CLARK TYPE "CY" starters have

No trick mounting problems

No crowded wiring spaces

No lack of concentric knockouts

No installation troubles

No parts back-removable

No tools needed for inspection

No loose screws in contact arm

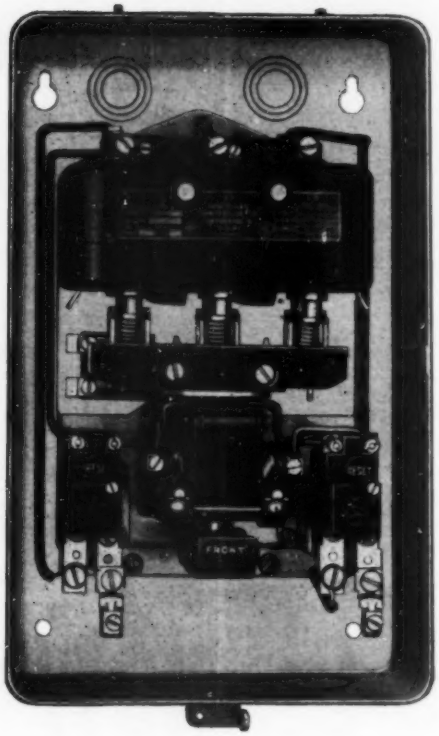
No single-break contacts

No carbonizing in arc chamber

No overload difficulties

No burning in steel arc space

No openings in top of arc shell



This string of positive *"NO's"* is supplemented by a long list of affirmatives that make CLARK Type "CY" the ideal starter for practically any AC motor application.

So—when you buy, you'd better try **CLARK TYPE "CY"**

THE CLARK CONTROLLER CO.

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Perspectives ~ DESIGN AND DEVELOPMENT

GUIDED MISSILES

The U. S. Guided Missile Program has dropped way behind schedule. More important, some scientists now believe that long range missiles can never accomplish their mission. So say engineers who have been working on the project for the past five years.

(Editor's Note: By guided missiles, these men mean weapons fired through the air and directed to a target by an internal mechanism. The U. S. is interested in three types: air-to-air (AAM), surface-to-surface (SSM), and ground-to-ground (GGM). The main difference between SSM and GGM is range; surface-to-surface missiles travel relatively short distances.)

Biggest delay has been in the development of a workable ground-to-ground, long-range (800 miles or longer) missile. Optomistic technicians expect it will be at least five years before they can evolve a production guiding mechanism. One observer thinks it could be 25 years at the present rate of progress.

The reason: today's electronic gear and mechanical components are not good enough to direct a missile with the almost unbelievable accuracy that is required.

In the GGM, the big problem is not getting the weapon to fly. It's knowing where the missile is so you can direct it. Once out of sight you can't trace it with the accuracy needed. Therefore, the U. S. wants a missile whose destination can be fed-in prior to firing.

NEGATIVE RESULTS

Despite an expenditure of almost two billion dollars, most of the accomplishments to date have been negative. That means scientists have proved some ideas for guiding devices won't work at all.

In designing such a mechanism, engineers first have to develop a system based on physical properties to guide the missile; they have to develop a method of putting target information into the system; and then they have to develop gear and instruments to make the system work.

Practically every large electronics and aircraft manufacturer is working in the field. They have three systems under study: (1) the star system, in which the missile takes bearings off the stars to guide itself during flight; (2) an inertial system that used gyroscopes and allied equipment to figure, by dead reckoning, where the weapon is going by where it has been; and (3) radio systems such as sending out two radio beams from different sources so they intersect over the target. The missile follows one beam and drops when it meets the second.

Each of these systems depends on basic physical properties like gravity, rotation of the earth, magnetism of the earth, etc. Major work done so far has been studying these properties.

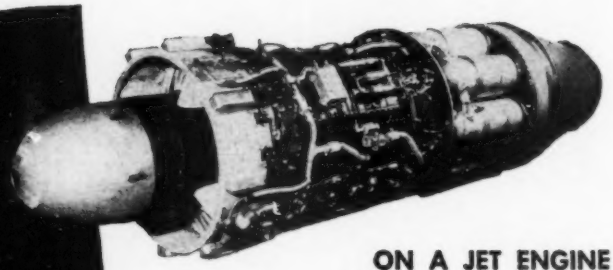
USEFUL PROPERTIES

Typical results: engineers have eliminated some properties that are unusuable because they cannot be instrumented or measured to the required degree of accuracy; they've found that some properties were not stable, so the guidance phenomena could not be repeated as desired; and they've narrowed down the radio spectrum to those frequencies and properties that might be useful.

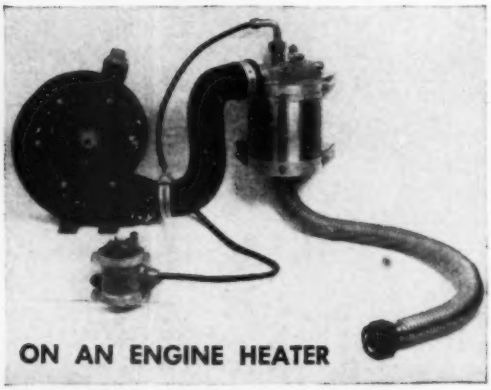
Now the problem is to build one satisfactory missile so the Defense

(Continued on page 115)

CMH FLEXIBLE METAL HOSE answer to 1001 design problems . . .



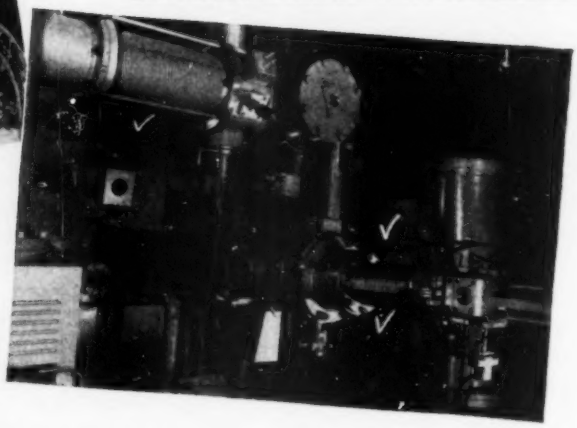
ON A JET ENGINE
(Photo courtesy, General Electric Co.)



ON AN ENGINE HEATER

ON A RECORD-HOLDING RACE CAR
(Photo courtesy, Cummins Engine Co.)

ON A POSITIVE ION ACCELERATOR
(Photo courtesy, High Voltage Engineering Corp.)



The Flexible Metal Hose Design Guide gives detailed data on types, sizes and characteristics of CMH hose. Write for your copy today, or see complete hose specifications in Sweet's Product Design File.

In any product where liquids or gases must be conveyed under conditions of vibration, expansion and contraction, misalignment or flexation, there is a design problem that can be answered with CMH Flexible Metal Hose.

CMH Flexible Metal Hose is available in a variety of corrugated and convoluted types, in steel, bronze, stainless steel and other alloys and in a complete range of diameters for every application. Whatever your product, if motion or misalignment exists in fluid conveying lines, it will pay you to consider CMH Flexible Metal Hose. Just send an outline of your problem and we will make recommendations.

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Flexon identifies CMH products that have served industry for over 50 years.

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Flexible metal hose

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Department can make a decision on which system to concentrate their efforts. One time-consuming operation is testing. After a missile is built it will take two years to adequately test it.

THE BIG DILEMMA

However the worry nagging top scientists is this: can a long range missile, with an excellent guiding mechanism, hit a target? German scientists who tipped the U. S. to this had trouble with the V-2 missile during World War II even though the ranges involved were relatively short, 150 to 200 miles. The problem stems from the fact that you can't locate a target accurately enough. Here is how scientists, who feel it's like trying to build a perpetual motion machine, explain the dilemma.

Since the missile depends on physical properties, the coordinates of the target must be figured in terms of these same properties. But scientific principles, like the uncertainty principle, and measuring instruments limit the accuracy with which the target position can be pin-pointed. This double error along with errors inherent in the guiding mechanism would prevent the missile from ever finding a predetermined target, expecially when the errors are magnified by the long ranges involved.

Despite this, the Defense Department has two uses in mind for GGM. They plan strategic bombing of industrial targets as well as tactical bombing of military targets in support fof ground troops.

According to some observers, companies are also having difficulty recruiting technicians for the missile program. The reason: engineers object to the misinformation about their work transmitted to the public and the lack of information exchange among men working on the project.

DEBUNKING PUBLICITY

Here is how technical men debunk popular ideas about guided missiles:

(1) last Fall the Navy announced the use of obsolete airplanes controlled by a second aircraft to bomb specific targets. They implied that this represented successful use of guided missiles, passe, but the forerunners of better weapons already developed. Engineers point out that this actually was a drone operation, not to be confused with a guided missile. Drone operation, they explain, is relatively simple because the parent is close enough to see the weapon and direct it.

(2) Publicists confuse the three types of missiles, implying success with one means success for all. Actually AAM represents a simpler design problem than the other because they are quite short ranged. The U. S. is in production of an air-to-air missile with a design reminiscent of marine homing torpedoss that search for their target.

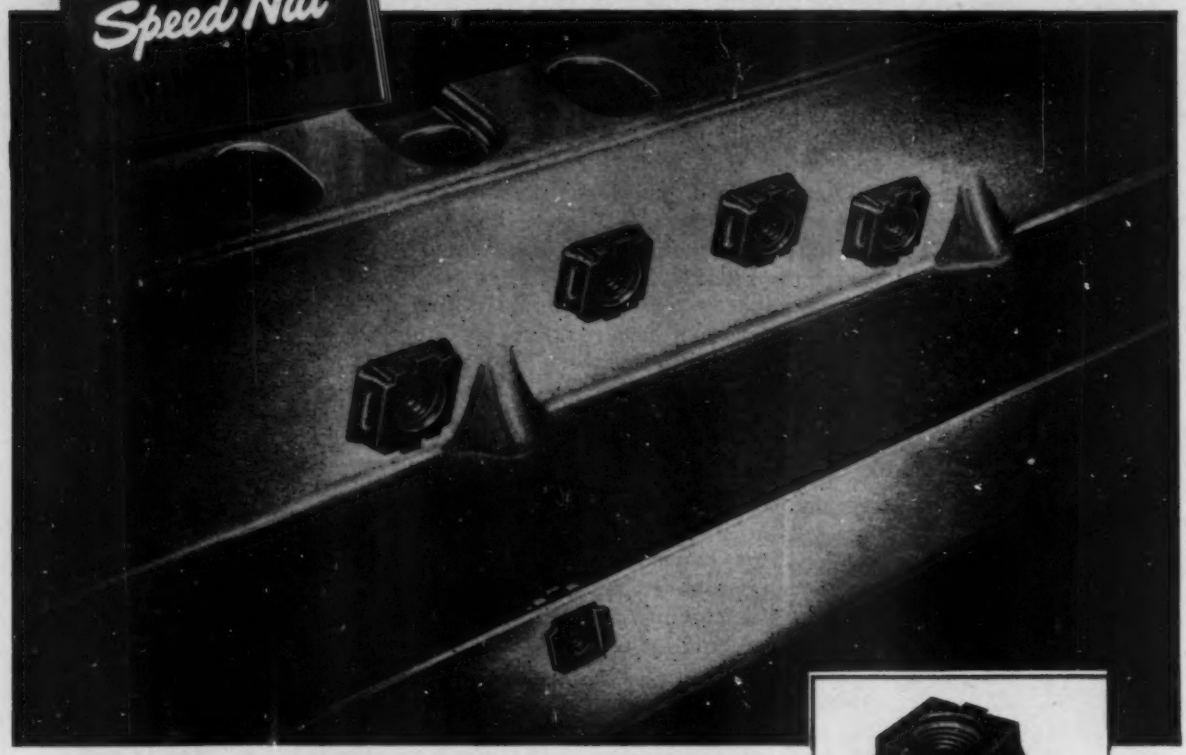
(3) An Army officer recently wrote that the Army, charged with developing SSM, had designed a short range missile guided by an inertial system. But he failed to point out that the production cost of this design was prohibitive. Other engineers claim that many problems still have to be solved in this type of system. For example, how to develop super precise bearings for mechanical equipment.

TOO MUCH SECURITY

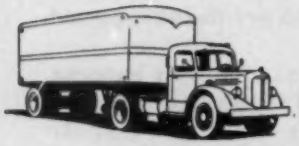
Too, government administrators are charged with poor coordination of the program, particularly concerning the dissemination of technical information. Observers claim that much of the security classification is applied to keep the U. S. public from knowing how slow progress has been rather than to hide details of missiles.

Researchers, cleared to read top secret information, complain that they don't know what other groups are doing. This causes delays and duplication. In some cases government contract officers have slipped their own copies of secret reports to missile engineers when the latter were unable to cut the government red tape that keeps information tied up.

FASTEST THING IN FASTENINGS®



Making light work of heavy-duty fastening ...with 57% savings!



G & O Manufacturing Company, New Haven, Conn., solves major fastening problem with 100% switch to Tinnerman SPEED GRIPS!

Here's how this famous maker of truck and heavy equipment radiators went right to the "core" of soaring production costs. G & O engineers specified SPEED GRIPS to replace the old method of welding nuts to radiator side panels for a big 57% assembly savings! In addition, this led to a big reduction in materials handling...eliminating costly shipping and servicing of units returned for repair due to weld breaks! Also eliminated was the need for expensive welding equipment, allowing the shift of skilled manpower to other production jobs!

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Nut Retainers

...replace welded nuts on the G & O radiator side panels as shown above . . . snap into bolt-receiving positions by hand...are ideal for use in blind locations, require no welding, clinching or staking; "float" prevents cross threading due to misalignment of holes. Available in a complete range of sizes to meet your needs.

Write today for your copy of "SPEED NUT Savings Stories", a booklet of typical SPEED NUT savings to industry: TINNERMAN PRODUCTS, INC., Box 6688, Cleveland 1, Ohio. *In Canada:* Dominion Fasteners, Ltd., Hamilton, Ont. *In Great Britain:* Simmonds Aerocessories, Ltd., Treforest, Wales. *In France:* Aerocessoires Simmonds, S. A., 7 rue Henri Barbusse, Levallois (Seine).

Imaginary Formulas

Engineers and scientists know that there are many problems that cannot be solved by formulas. Stresses and deflections in many framed structures simply cannot be calculated. The common connecting rod defies the best efforts of stress analysts. However, there is always the inexperienced man who firmly believes "there must be a formula" and then not being able to find one he attempts to create one. Perhaps one of the weaknesses of our educational system is that we are not taught that "you can't figure everything".

The wonders attributed to the modern digital and analogue computers have misled many people to believe that now everything has been changed and now anything can be calculated. To the contrary, regardless of the amazing capacity of computers, it is still necessary to establish the formulas or relationships that the computer is to unravel.

Scientific accuracy of solution cannot be expected when the problem involves too many non-related and indeterminate variables. These might include human behavior, the weather, and all kinds of erratic quantities. And ironically, when conditions become too pure, behavior may be erratic. Chemically pure water at standard atmospheric pressure does not boil at 212F nor does it freeze at 32F. Such are the mysteries of nature.

The story is told of the mathematics professor whose wife had told him that their first child was on the way. That night the prof started to apply his mathematical brain to the development of the formula that would foretell the sex of the child. In his mental concentration the prof dozed off to sleep but his subconscious mind kept working and in his dreams he developed a wonderful formula that would solve the great problem that has vexed mankind from the dawn of civilization.

The next morning he told his wife all about the wonderful formula, but added, "There is only one difficulty still to solve. The formula contains the square root of minus one, which, you know dearest, is an imaginary quantity. And try as I might I have not been able to get the minus one out from under the radical, so the formula still gives me an imaginary result."

"Darling", cooed the wife, "Your formula is just too perfect. I just found out that my pregnancy was imaginary."

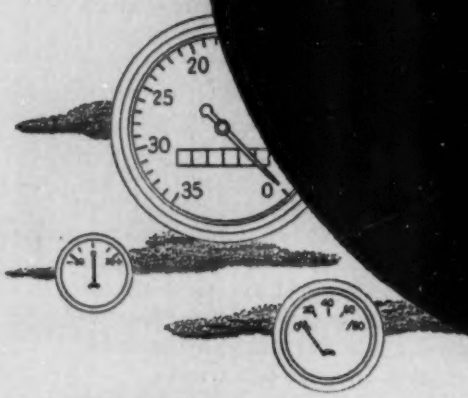
And so it is with too many formulas that are concocted to solve the unsolvable. Someplace in them is hidden, literally or figuratively, the square root of minus one, which makes the whole equation just an imaginary quantity. Designs and decisions should not be based on imaginary quantities and we must reconcile ourselves to the fact that there are many problems that cannot be solved by a formula.

For the solution of many of the problems of stress magnitudes and distribution engineers use experimental stress analysis. There is nothing more accurate than a running test to determine the fatigue life of a structure. There are formulas and calculus methods for figuring the cubical contents of a bottle, but it is much simpler to fill the bottle with water and measure the volume in a graduate glass.

Experience, common sense and basic knowledge are the most powerful tools for the solution of technical and scientific problems. On the basis of this trinity the engineer can always decide correctly which procedure to use for the solution of his problem. In every instance he will avoid trying to use formulas where formulas are not applicable. And of course, he will never try to use an imaginary formula.

George F. Zodenholz

ACCENT ON ACCURACY

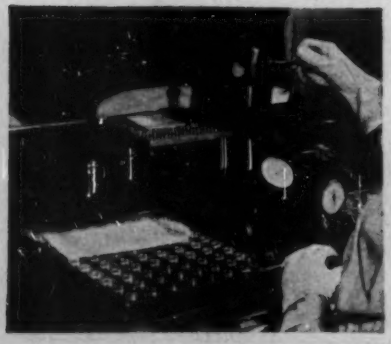


WITH MICROSCOPIC PRECISION

Through experience, the aircraft instrument manufacturer knows that ball bearings are best for low friction support of many moving parts and shafts, both in low torque and high speed applications.

Such sensitive instrumentation requires the highest standards of accuracy and careful craftsmanship in precision bearing production. The finest facilities for this type of work are maintained by New Departure . . . where ball bearings are tested and inspected with the latest scientific equipment . . . where they are assembled and packed under rigidly controlled standards of cleanliness.

Specify New Departure ball bearings for all instrument applications. In the air, and everywhere, keep your eye on the BALL to be sure of your BEARINGS!



Scientific methods at New Departure instrument bearing plants assure precision production. Only workers with gloved hands, tweezers or special holding devices touch bearings in this dust-free area.

NOTHING ROLLS LIKE A BALL

NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT
Also makers of the Famous New Departure Coaster Brake

Small Rivets *for* Big Jobs

High-speed automatic-feed riveting machine.

ROBERT M. GORDON
The Milford Rivet & Machine Company

- How to use tubular, semi-tubular, and small diameter rivets for joining low cost, high production assemblies. Design tips to insure good joints.
- Recommended clinch allowances, hole clearances, and joint configurations for various rivet sizes.
- Suggested modifications to improve appearance, simplify application, or permit multiple purpose use.

RIVETING, one of the oldest methods of fastening metal parts, is also one of the most economical. Not only is the cost of the rivet itself less than most types of threaded fasteners, but the design of high-speed riveting machines with automatic hopper feeds and work handling equipment, above, has advanced to the stage where the entire process is competitive with or cheaper than many other established joining methods.

Production figures are extremely difficult to estimate inasmuch as they depend on many factors surrounding the riveting operation. The standard type of riveter can feed and drive a rivet as fast as the machine can be tripped; it then becomes a problem of the complication of the assembly along with the work handling problem at the machine.

In addition to low cost and speed of application, small tubular and solid rivets, which are the basis of this discussion, can be used to advantage when joining assemblies comprised of non-uniform thickness, dissimilar or non-metallic materials, or a variety of metals in lightly loaded structures. Such products as home appliances, radios, television sets, electrical controls, office equipment, business machines, cutlery, automobiles and automatic accessories, agriculture implements, wiring devices, and military hardware including fuses, bomb parts, gun parts, and aircraft sub-assemblies are commonly fastened by this method.

TYPICAL TUBULAR, SEMI-TUBULAR, AND SOLID RIVETS AND

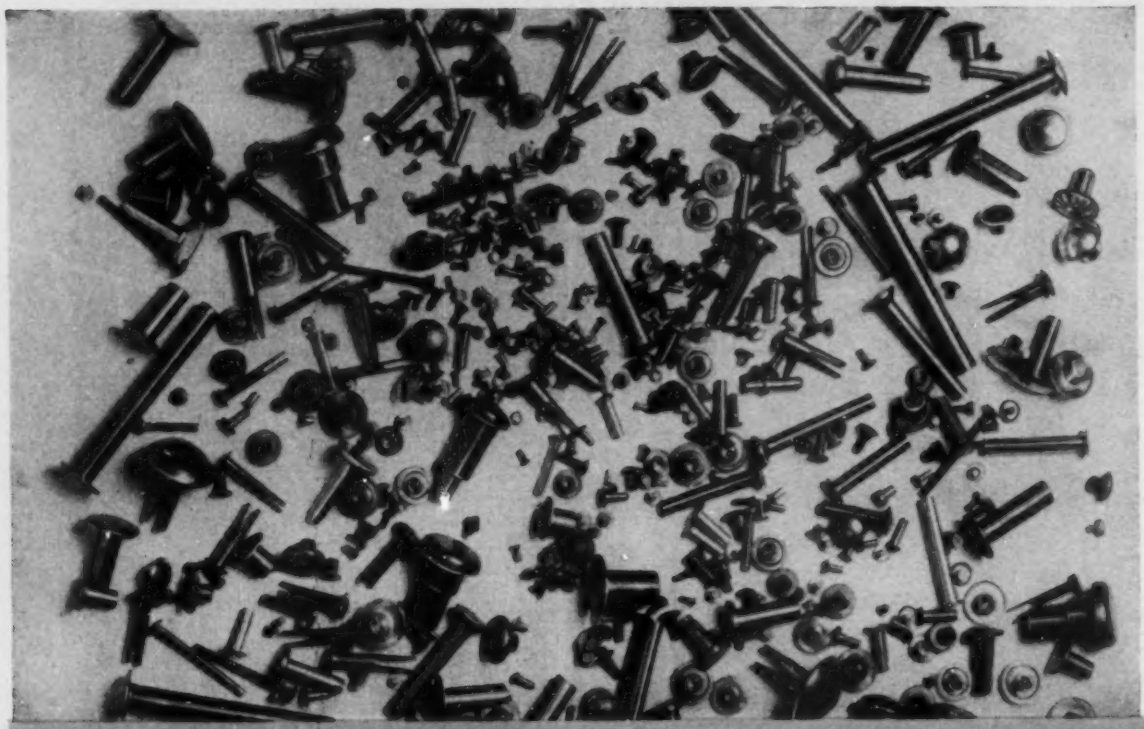


Fig. 1—Basic types of tubular rivets. See text for advantages, applications, and limitations. Now in the process of being standardized by the ASA, these also are available in a wide variety of specials.

Basic Types of Rivets

Basically, rivets are produced from wire by the cold heading process. They therefore can be made from any material that is sufficiently ductile for cold-heading, including:

1. Low carbon steel, such as AISI 1010 and 1006, which probably account for 95 percent of the applications involving ferrous materials.
2. Alloy steels and stainless Types 302 and 430.
3. Brass in almost all alloys from 65-35 to rich low alloys. Also, in copper from oxygen free to electrolytic grade including tellerium copper.
4. Aluminum in 2-S, 3-S, 17-S, 24-S, and 56-S, and other alloys as specified by major producers.
5. Nickel and Monel.
6. Precious metals such as pure and coined silver.
7. Lead, zinc, and other low melting point alloys, which often are used for fusable plugs that melt when exposed to high temperatures.

Production is on single, double, or triple blow headers depending on the volume of material necessary to be upset. The tubular rivet is either *extruded* or *drilled,* the former being limited as to length and diameter by the capacity of the manufacturer's equipment. While somewhat stronger than drilled types, it cannot readily be made in some highly alloyed ferrous metals.

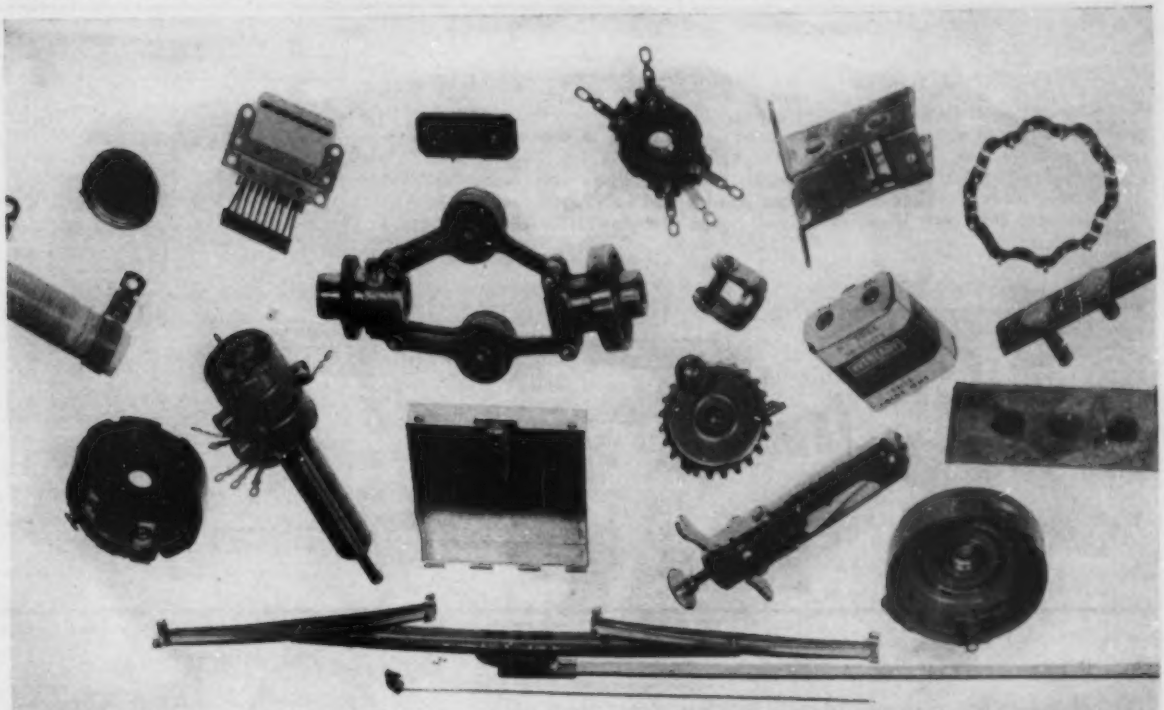
Extruded rivets also are characterized by the shape of the hole, which is tapered to provide the necessary draft to strip the rivet off the extruding pin. Some taper is always necessary, although the amount can be so small that walls are nearly parallel.

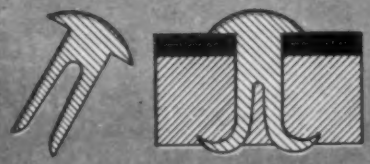
These semi-tubular—sometimes shallow drilled rivets—are perhaps the most widely used of all types. They are used for assemblying plastic, wood, sheet metal, and aluminum whenever holes have been punched prior to setting and whenever the full shear strength of the fastener is required.

Drilled rivets, as indicated above, can be either deep or shallow drilled. The deep drilled or full tubular type has a cavity extending practically to the head, while the shallow type has a cavity only sufficiently deep to allow setting or clinching.

The full tubular type is best suited for use with materials such as plastics, leather, canvas, or wood, in which the rivet must pierce its own hole. The deep drilling allows the slug of material to compress inside the rivet, providing sufficient metal for clinching.

SOME OF THE PRODUCTS TO WHICH THEY ARE ADAPTED





Split or Bifurcated

Advantages and Limitations of Riveted Joints

ADVANTAGES

1. Production rates are high.
2. Initial and maintenance costs for equipment are low.
3. Either metallic or non-metallic materials can be joined.
4. Dissimilar metals and assemblies having a number of parts with non-uniform thickness can readily be fastened.
5. The fastener, being a cold-headed part, has the uniform grain structure and inherent strength of a forging.
6. Unskilled labor can be used to operate equipment.
7. The rivet can be made of a variety of materials ranging from Monel or Inconel to lead or zinc.
8. The rivet can be used not only as a fastener but as a pivot, cam follower, electrical contact, or other functional component.
9. There is no heat distortion or crystallization of the base metal.

LIMITATIONS

1. Parts, once fastened, cannot easily be dissembled.
2. The tensile and fatigue strengths of joints made with split, tubular, or semi-tubular rivets are considerably lower than bolted or welded assemblies.
3. Joints normally are neither watertight or airtight.
4. Protruding rivet heads may be undesirable in food machinery, chemical equipment, or other sanitary assemblies.

A third class of rivet is the bifurcated or split type. The manufacturing operations used to make these parts produce rivets which are identified as "sawed" or "punched". The broaching or sawing operation produces a stronger rivet inasmuch as the prongs or legs are not distorted. This characteristic makes it ideal for piercing fibre, wood, or thin gage sheet metal. It has been used successfully in piercing steel assemblies having an approximate overall thickness of 0.040 in. The punched rivet cannot be used in the heavier applications with as much success. However, it is suitable for cardboard, canvas and lighter piercing operations.

The full tubular and bifurcated rivets are often clinched into a cap to obtain the same general appearance on either side of the riveted part or to obtain a stronger assembly and also a smooth, neater surface.

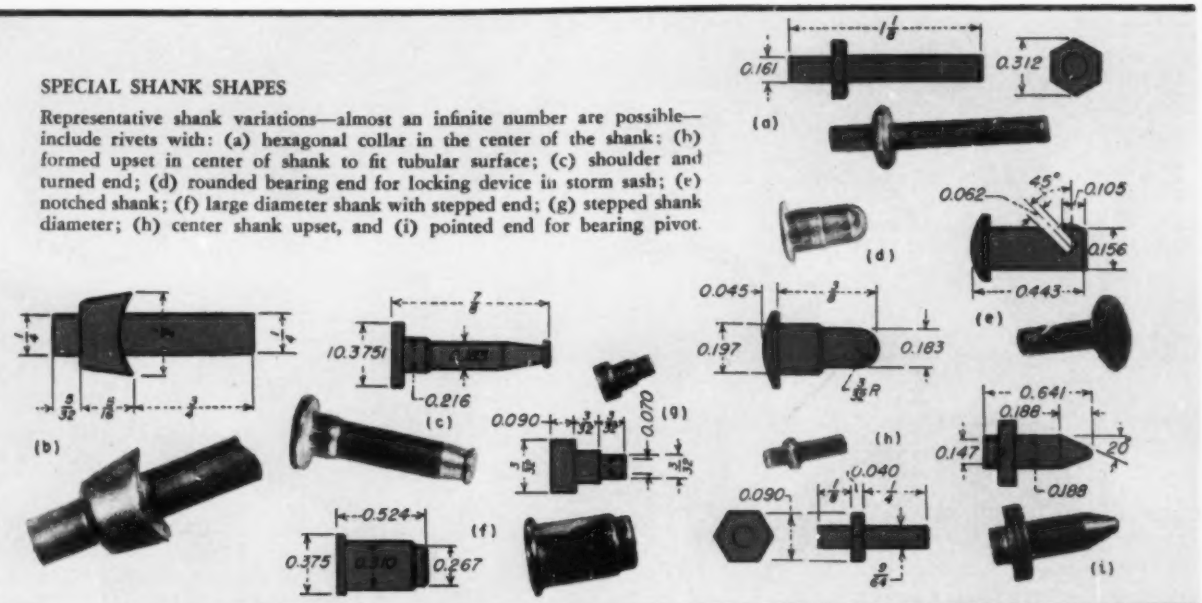
Finally, a fourth basic type of tubular rivet is formed from a combination of a deep-drilled part and a solid or blank rivet. The relative sizes of the drilled hole and blank diameter are combined in such a manner as to produce a compression or press fit. This combination produces a fastener with the same appearance on each end.

The greater portion of compression rivets are made with "trimmed" heads. The rivets are hopper fed in automatic equipment and, one at a time, the periphery of the heads are shaved

TABLE I—SPECIAL TUBULAR, SEMI-TUBULAR AND SOLID RIVETS

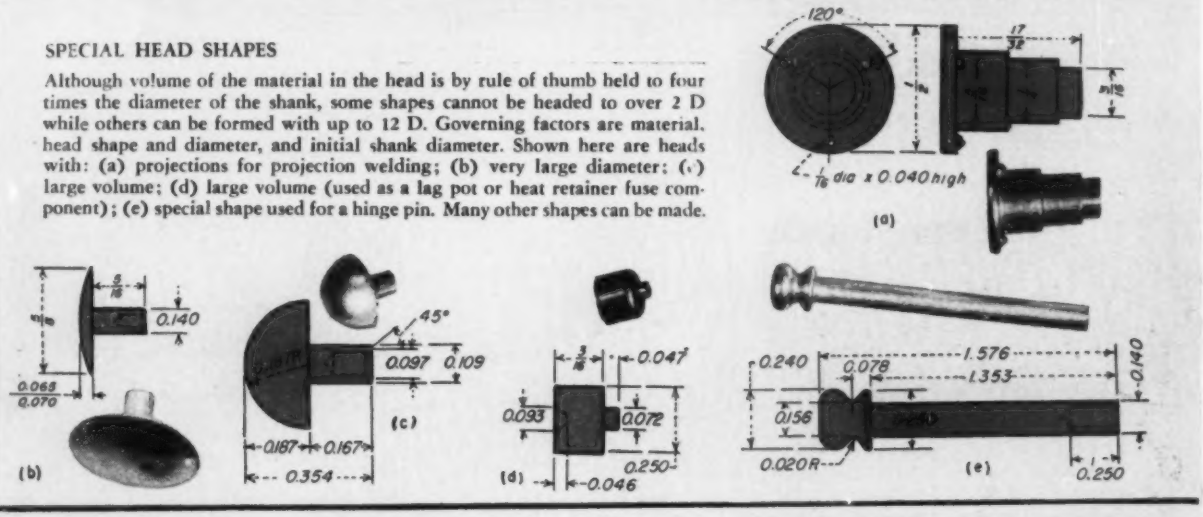
SPECIAL SHANK SHAPES

Representative shank variations—almost an infinite number are possible—include rivets with: (a) hexagonal collar in the center of the shank; (b) formed upset in center of shank to fit tubular surface; (c) shoulder and turned end; (d) rounded bearing end for locking device in storm sash; (e) notched shank; (f) large diameter shank with stepped end; (g) stepped shank diameter; (h) center shank upset, and (i) pointed end for bearing pivot.



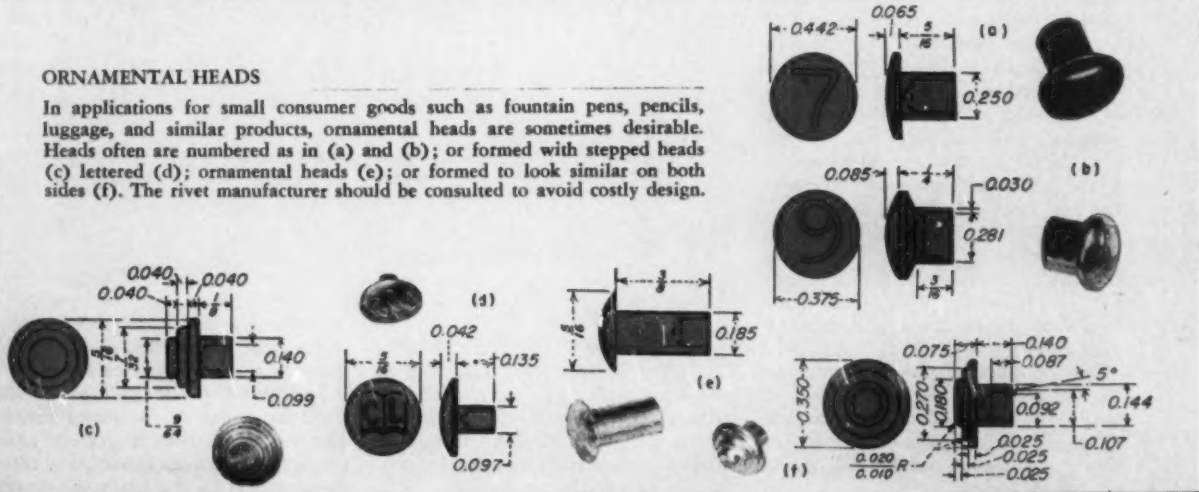
SPECIAL HEAD SHAPES

Although volume of the material in the head is by rule of thumb held to four times the diameter of the shank, some shapes cannot be headed to over 2 D while others can be formed with up to 12 D. Governing factors are material, head shape and diameter, and initial shank diameter. Shown here are heads with: (a) projections for projection welding; (b) very large diameter; (c) large volume; (d) large volume (used as a lag pot or heat retainer fuse component); (e) special shape used for a hinge pin. Many other shapes can be made.



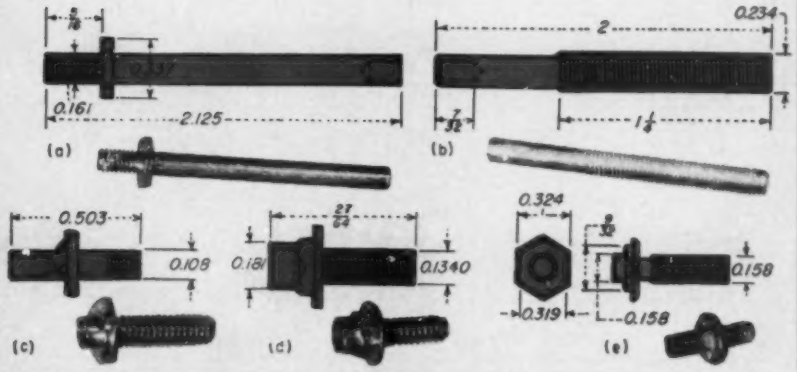
ORNAMENTAL HEADS

In applications for small consumer goods such as fountain pens, pencils, luggage, and similar products, ornamental heads are sometimes desirable. Heads often are numbered as in (a) and (b); or formed with stepped heads (c) lettered (d); ornamental heads (e); or formed to look similar on both sides (f). The rivet manufacturer should be consulted to avoid costly design.



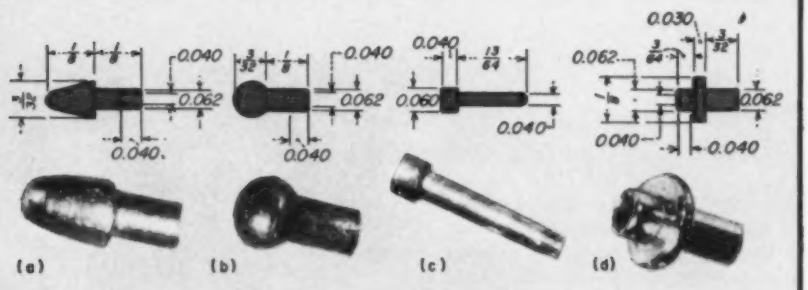
THREADED RIVETS

Frequently, rivet shanks are threaded or knurled to permit them to be used as studs for subsequent sub-assembly of parts. Illustrated are representative examples, including a stacking stud and rivet for electrolytic condensers, a transformer contact stud, an adjusting screw for a contact point, and others. The shank is roll threaded in a secondary operation.



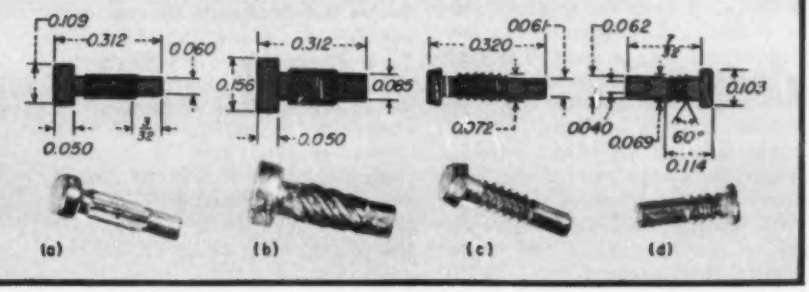
SMALL MULTI-PURPOSE RIVETS

These rivets act not only as a fastener but as an assembly component: (a) head acts as cam follower in mechanism; (b) ball head used to advance barrel cam and turning; (c) stop for a gage pointer; and (d) electrical contact for television channel selector. Other examples include detents, and locating points.



ELECTRICAL CONTACTS AND INSERTS

Common practice in many applications is to use a rivet as an electrical contact, particularly in molded or laminated non-metallic materials. Of these four rivets, (a) has a straight flute or knurl for a pressed fit; (b) has a drive screw thread; (c) and (d) have annular grooves to hold the rivet in a molded part. Besides these conventional designs there are special ones.



or trimmed to be closely concentric with the shanks and closely held to diameter. Heads are also trimmed on secondary operations by means of "punch trimming." These operations produce a rivet ideal for cutlery or utensil assemblies where the heads must fit closely in counterbored holes, so as not to allow food particles or dirt to collect. Also, since the driving force can be closely controlled, the compression rivet has little tendency to split the wood or plastic base materials.

All of the above types of rivets, illustrated in Fig. 1, fall under the general classification of oval head rivets. To date, each manufacturer has established his own specifications and modified dimensions to meet customer requirements. However, oval head rivet standards are now in the process of being set-up by the ASA. As a matter of fact, tentative standards have been forwarded to various manufacturers and committee groups for comment, and probably will be approved in the near future.

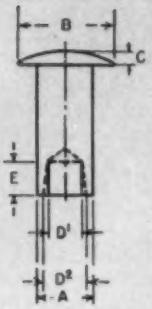
Special Rivet Designs

The wide variety of special rivets that can and are being produced fall into several broad categories, one of which is typified by shoulder rivets. The combination of a tenon and shoulder can be produced through a broad range of sizes, as required in a particular assembly. Shoulder rivets and similar fasteners are made in several ways. The tenon can be "extruded" in the cold upset operation, by "squirting" the tenon diameter down into the counterbored die, from wire of the rivet shoulder diameter. This method of forming leaves a small extruding angle between the shoulder and tenon of the rivet. The shoulder can also be formed starting from wire of the tenon diameter, and filling up the shoulder as the head is formed. This produces a relatively square shoulder formation. If neither of these operations can be employed, the blank is headed and the tenon turned down in a subsequent operation, similar to the turning of the heads as noted.

Other types are produced of precious metal such as coin silver, for electrical contacts; with knurled or fluted shanks that can be used as inserts in molded or die cast parts; with special long, short, or shaped shanks that can be used as pivots or cam followers; with ornamental heads for pens, pocket lighters, or similar products; or with large diameter or special head shapes. (See Table I).

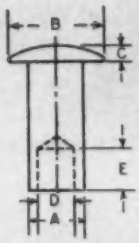
TABLE II—RECOMMENDED HOLE SIZES AND CLINCH ALLOWANCES

EXTRUDED



A	B	C	D¹	D²	E	Maximum Clinch Allowance	Hole in Work
0.059	0.125	0.023	0.038	0.045	0.044	0.040	0.064
0.087	0.146	0.024	0.056	0.067	0.065	0.060	0.093
0.087	0.160	0.024	0.056	0.067	0.065	0.060	0.093
0.097	0.187	0.032	0.063	0.074	0.072	0.068	0.104
0.120	0.218	0.033	0.078	0.093	0.090	0.084	0.128
0.120	0.281	0.042	0.078	0.093	0.090	0.084	0.128
0.144	0.281	0.042	0.094	0.110	0.108	0.100	0.154
0.144	0.312	0.045	0.094	0.110	0.108	0.100	0.154
0.144	0.375	0.062	0.094	0.110	0.108	0.100	0.154
0.184	0.312	0.062	0.120	0.140	0.138	0.125	0.191
0.184	0.375	0.062	0.120	0.140	0.138	0.125	0.191

DRILLED



0.097	0.187	0.032	0.067	0.075	0.068	0.104
0.120	0.218	0.033	0.082	0.096	0.084	0.128
0.120	0.281	0.042	0.082	0.096	0.084	0.128
0.144	0.281	0.042	0.099	0.105	0.100	0.154
0.144	0.312	0.045	0.099	0.105	0.100	0.154
0.144	0.375	0.062	0.099	0.105	0.100	0.154
0.184	0.312	0.062	0.128	0.147	0.125	0.197
0.184	0.375	0.062	0.128	0.147	0.125	0.197

Riveting Techniques and Tools

Once the correct type of rivet has been selected, the correct tools must be employed in the setting operation. These tools are part of the rivet setting equipment and have a definite relationship to a particular rivet.

Before attempting to analyze the tools, it is necessary to know the type of clinch or set required of the various rivets. Semi-tubular rivets ordinarily are "roll-set". This clinch can be formed directly against the work, or a washer, or as in some cases, away from the base stock so as to form a pivot pin or axle.

Deep drilled or full tubular rivets are usually "star-set". This particular tool is made in the form of a rosette or star which cuts the rivet, usually into 6 or 8 even segments. The deep drilled rivet generally punches its own hole, being driven and clinched in one operation.

The bifurcated rivets are usually set by driving them against a solid tip, inasmuch as they normally pierce the work. The protruding prongs are formed in the solid tip, forming back into the work to provide as smooth a clinch as possible. The caps are held in a solid tip and the piercing tubular or split rivet is clinched into the cap.

Variations of these anvils are endless; however, the theory and practice remain the same regardless of shape, size or type. Several of the standard tools most generally used are pictured in Fig. 2 to illustrate their construction and form.

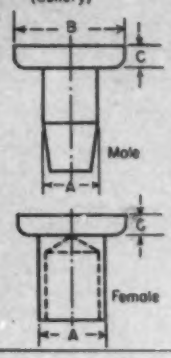
A driver is located in the ram or spindle of the machine and suited to rivet head diameter and shape. Normally, the driver diameter is under the head size of the rivets by 0.005 to 0.025 in. A head diameter of 0.085 in. requires a driver diameter of 0.080 in.; whereas, a head diameter of 0.50 in. will have a corresponding driver diameter of approximately 0.475 in. or about 0.025 in. smaller.

The working end of the driver is formed to the contour of the rivet head. Usually a "set edge" is provided to reduce cracking. The straight portion of the driver is held to the predetermined diameter for a length

roughly equivalent to the length of the jaw which supports the rivet during driving. Above this point the driver is shaped according to the design of the tool. This is usually a standard construction depending on whether the tool is an insert or solid spindle type.

The subject of tooling, of course, covers many additional considerations and could, of course, be covered adequately only in an article devoted exclusively to that topic.

COMPRESSION (Cutlery)



MALE			FEMALE					
A	B	C	A	B	C	Expanded* Diameter	Hole Thru* Work	Hole Thru* Blade
0.125	0.250	0.044	0.151	0.250	0.044	0.162	0.172	0.168
0.125	0.312	0.044	0.151	0.312	0.044	0.162	0.172	0.168
0.125	0.343	0.044	0.151	0.343	0.044	0.162	0.172	0.168
0.125	0.375	0.044	0.151	0.375	0.044	0.162	0.172	0.168
0.144	0.312	0.050	0.195	0.312	0.050	0.206	0.216	0.212
0.144	0.343	0.050	0.195	0.343	0.050	0.206	0.216	0.212
0.144	0.375	0.050	0.195	0.375	0.050	0.206	0.216	0.212
0.144	0.437	0.050	0.195	0.437	0.050	0.206	0.216	0.212

BIFURCATED

A	B	C	Clinch Allowance
0.091	0.148	0.022	0.106
0.080	0.156	0.022	0.093
0.118	0.218	0.034	0.125
0.118	0.312	0.055	0.125
0.146	0.312	0.046	0.156
0.146	0.375	0.062	0.156

* Expanded diameters are subject to wide variation due to the tolerances of the solid and tubular rivets. Hole diameters should be checked carefully before assembly.

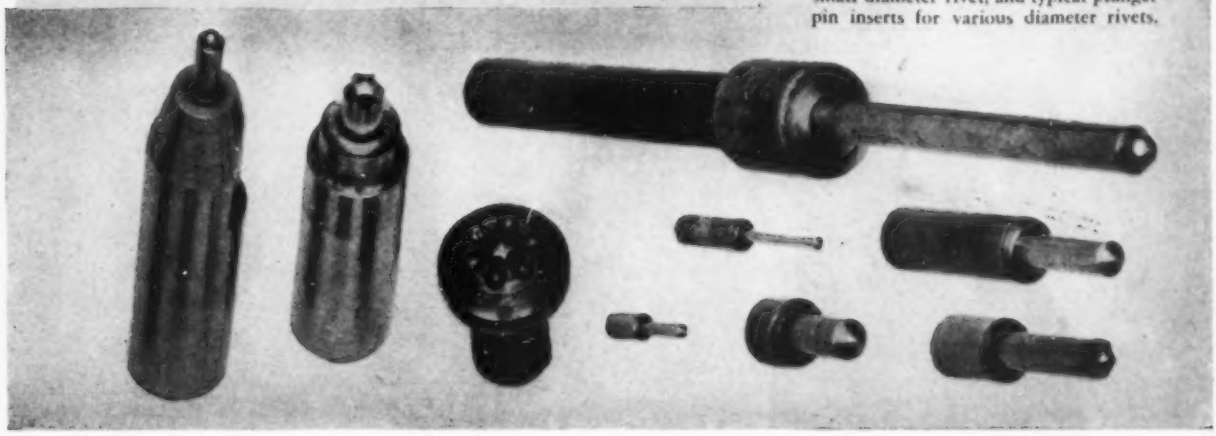


Fig. 2—Types of anvils that can be used to set tubular, semi-tubular, and split rivets include large type rollset, solid star set tip, split rivet tip, small type rollset, special split tip, solid special cut star set, special cut roll set, star set plunger type set, special cut roll set for small diameter rivet, and typical plunger pin inserts for various diameter rivets.

Rivet and Joint Design Requirements

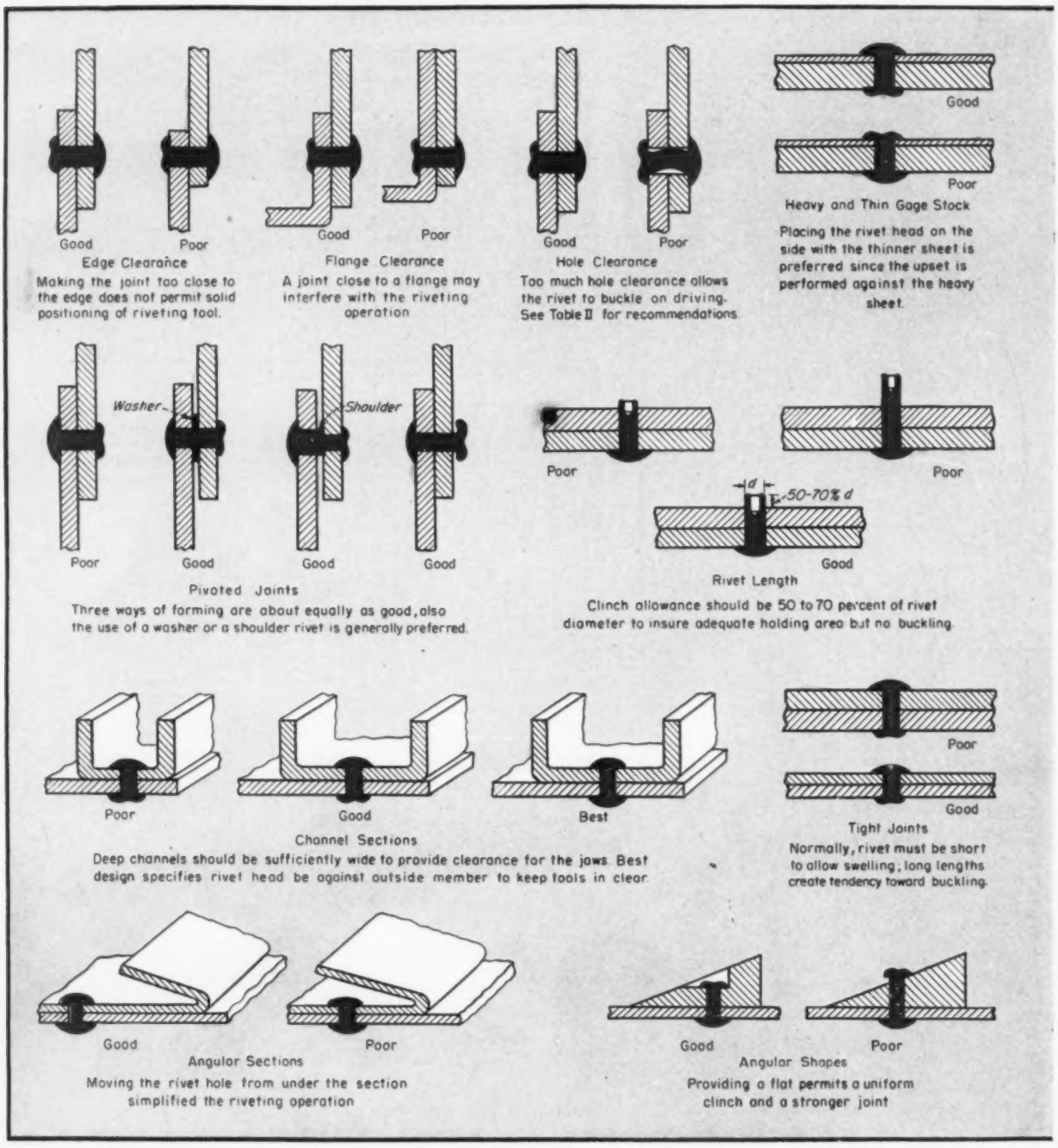
Roll-sets are designed to clinch a predetermined portion of the rivet shank. It generally holds true that a maximum allowance of 70 percent of the shank diameter added to the compressed material thickness will produce the required rivet length. When the correct clinch allowance has been determined, a full round set without excessive shank distortion is obtained. The tubular portion of the rivet should be absorbed in the clinch leaving a solid shank thru the assembly, affording maximum shear strength.

Often times it is necessary to sacrifice tool life to produce an extremely tight joint, where the rivet must not only clinch, but also swell throughout its entire length, locking tightly in the assembly. This can only be obtained in the relatively short lengths of rivets inasmuch as the long lengths will tend to buckle.

In figuring the clinch allowance for a split or deep drilled rivet, it is standard practice to add a maximum of 100 percent of shank diameter to the compressed assembly thickness. Due to the fact that these types are most commonly used for piercing compressible materials, it is advisable to determine rivet length by actual test.

Another and equally important con-

TABLE III—DESIGN TIPS FOR RIVETED JOINTS

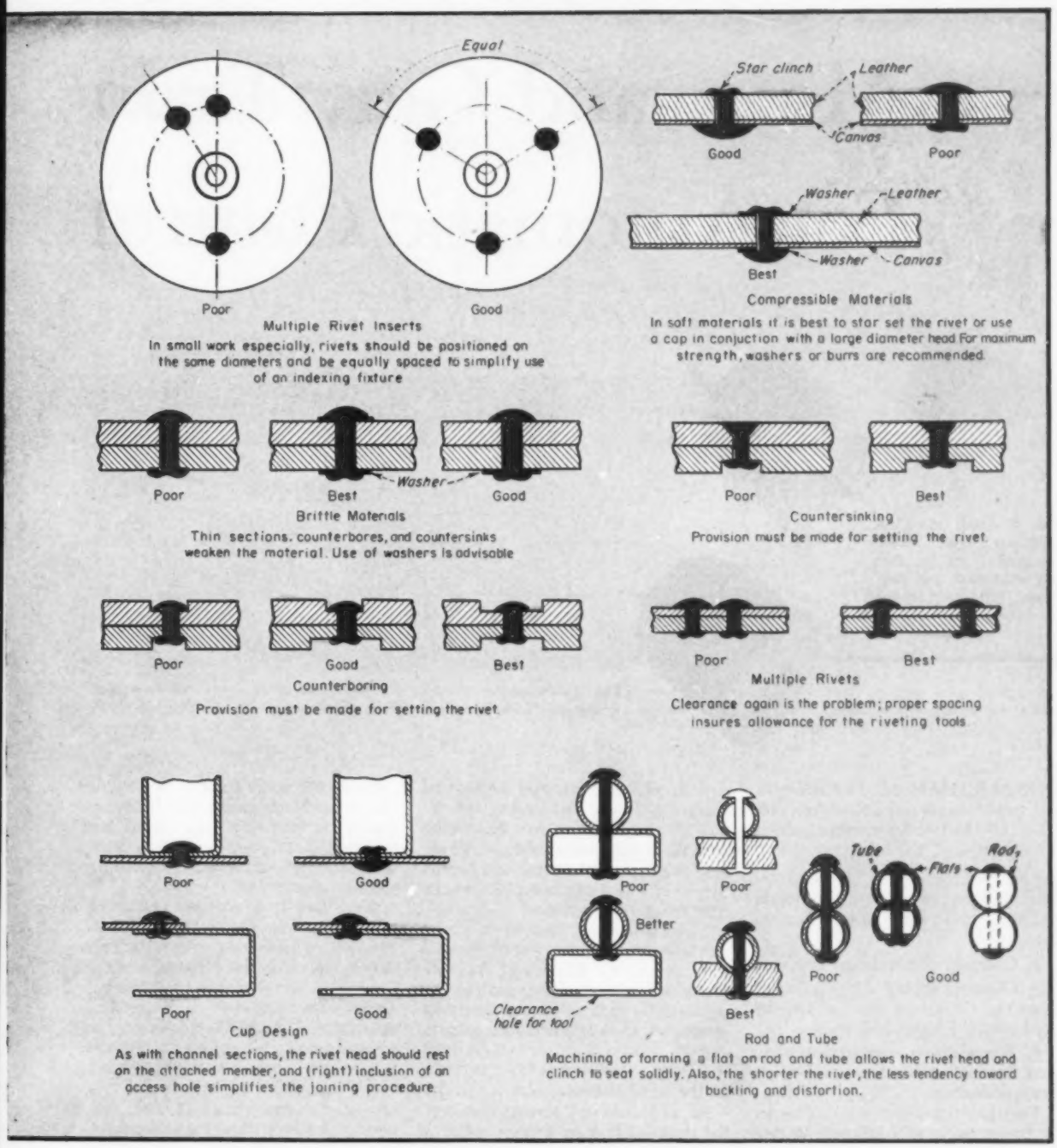

Good
Poor
Edge Clearance
Making the joint too close to the edge does not permit solid positioning of riveting tool.
Good
Poor
Flange Clearance
A joint close to a flange may interfere with the riveting operation
Good
Poor
Hole Clearance
Too much hole clearance allows the rivet to buckle on driving. See Table II for recommendations
Good
Poor
Heavy and Thin Gage Stock
Placing the rivet head on the side with the thinner sheet is preferred since the upset is performed against the heavy sheet.
Washer
Shoulder
Poor
Good
Good
Good
Pivoted Joints
Three ways of forming are about equally as good, also the use of a washer or a shoulder rivet is generally preferred.
Poor
Poor
d
50-70% d
Good
Rivet Length
Clinch allowance should be 50 to 70 percent of rivet diameter to insure adequate holding area but no buckling
Poor
Good
Best
Channel Sections
Deep channels should be sufficiently wide to provide clearance for the jaws. Best design specifies rivet head be against outside member to keep tools in clear
Poor
Good
Tight Joints
Normally, rivet must be short to allow swelling; long lengths create tendency toward buckling.
Good
Poor
Angular Sections
Moving the rivet hole from under the section simplified the riveting operation
Good
Poor
Angular Shapes
Providing a flat permits a uniform clinch and a stronger joint

sideration is the hole clearance allowed for the rivet. Too much clearance will allow buckling when the rivet is set; too little will prevent the rivet from being driven. In Table II are listed recommended clinch allowances and hole clearances for various rivet types and dimensions. Allowances of the same order hold for other sizes.

Designs requiring rivets should be examined for other clearances required. Keeping in mind that the jaws must lower the rivet to the work, interference around the rivet heads should be kept to a minimum. Right angle or channel formed pieces should provide adequate clearance for the jaws. The same situation may exist when fastening cupped or drawn shells when there is not enough room for the jaws to lower. Formations of this type are often a problem to load on the riveting machines.

Adequate clearance also should be allowed around the rivet clinch, so as to utilize tools of maximum strength. There are definite limitations as to the sizes of roll-sets depending on the rivet involved and, if insufficient material is provided around the setting tool due to design limitations, the tool will quickly chip and crack at this point.

If the rivet is not getting through the work, it may be due to several conditions. First, the hole size in the



work should be checked to see if the rivet is swelling and locking at the start of the clinch. Usually, if this condition exists, the head will remain slightly above the work. This condition can be checked by grinding through the assembly, for, although the head may be flush with the work, the shank may be compressing and bulging throughout its length. If the hole size is correct and the roll-set form in good condition, it will probably be necessary to provide a pressure pad in the form of a rubber ring or spring located around the roll-set. These pads are most commonly used with soft rivets such as aluminum and silver.

Riveting equipment ranges in size depending on the capacity of equipment. Assemblies requiring small rivets must be designed so that the riveted points are readily accessible to the tools and in keeping with the throat depth and clearances of available equipment. This also holds true for the larger rivets which in turn will require larger machines and more rugged construction, again affecting the clearances to be allowed.

These and other design tips are illustrated in Table III. As a matter of record, many additional remarks could be added. However, their value would be limited to specific rivets and setting equipment.

Motor and Gear Train For Automatic Control

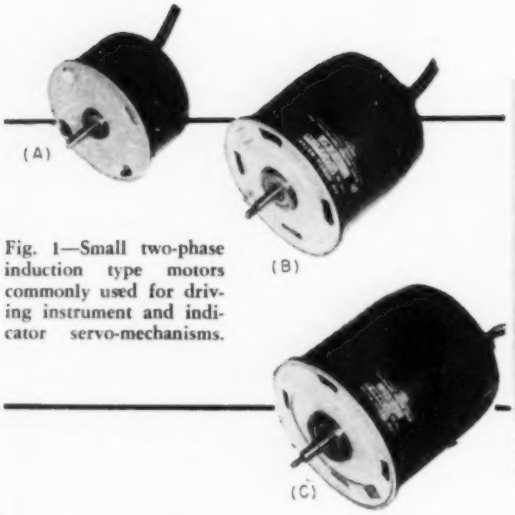


Fig. 1—Small two-phase induction type motors commonly used for driving instrument and indicator servo-mechanisms.

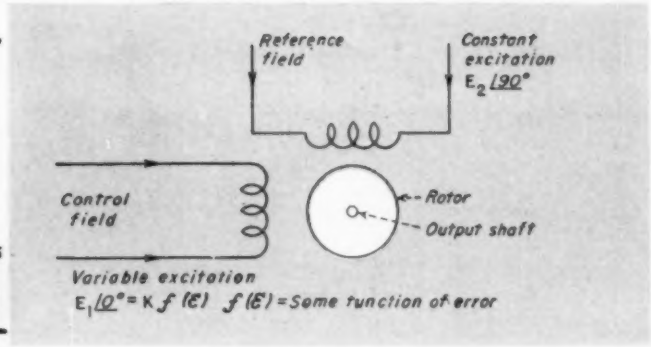


Fig. 2—Excitation of reference field and control field of two-phase drivemotor. Amplifiers supply variable voltage for the control phase.

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THREE FUNDAMENTAL CONSIDERATIONS govern the selection of a motor and a gear train for a servomechanism application:

1. Compatibility with environment.
2. Dynamic characteristics sufficient to permit the achievement of the desired overall bandwidth.
3. Torque-speed characteristics to meet the acceleration and velocity output specification.

The third consideration determines the power rating of the motor. Within the type of motors available in that rating, the optimum motor is selected on the basis of the results of the first consideration. Finally, the gear train ratio that best matches the motor to the load is selected on the basis of the third and other considerations.

This discussion will explore the types of servomotors generally available, outline their characteristics, analyze the problem of matching the motor to the load through a suitable gear train, and present a graphical procedure for solving this problem. This discussion will not attempt, because of space limitations, to correlate the potential servomechanism bandwidth with the motor characteristics. All the motors discussed, however, can be employed in reasonably fast (10 cps resonant frequency) systems.

Motors, clutches, and motor-generator systems for driving servomechanisms include the following: A-c two-phase induction motors; d-c motors; magnetic clutches; motor-generator electric systems; and hydraulic motors.

A-C TWO-PHASE INDUCTION MOTORS. In the small size necessary for instrument and indicator servomechanisms, the common type of driving motor is the two-phase induction motor, Fig. 1. The reference phase, as shown in Fig. 2, is continuously excited by a constant voltage, generally from the a-c power line. The control phase is supplied with a variable voltage obtained from electronic or magnetic amplifiers. Design data covering the motors shown in Fig. 1 are given in Table I.

Two-phase induction motors are available in input power size ratings from 3 to 2000 watts. Output torque for these sizes ranges from a stall torque of 0.3 to 300 ounce in. Maximum speeds range from 3,000 to 12,000 rpm. Many induction motors are manufactured with a tachometer mounted directly on the output shaft. This arrangement facilitates stabilizing the servomechanism.

Since they have no commutators or slip rings to wear out, two-phase induction motors have long life and a high degree of reliability. Excessive rotor heating, however, may cause bearing failure. This hazard can be reduced to safe values by adhering to reasonable ratings and by providing cooling arrangements when necessary. In sizes larger than about 80 watts input, it is necessary to cool almost all these motors. The larger motors, consequently, are usually manufactured with fan motors in the same housing.

The ratio of frame dimensions to the rating of two-phase induction motors increases rapidly in the sizes larger than 80 watt input, thus imposing proportionately greater inertia and slowness of response. The cost, size, and complexity of the driving stage also increase with the dimensions.

D-C MOTORS. Servomotors operated by direct current are built in two types: (1) Split-field construction; and (2)

Selection Systems

Table I – Inertia and Torque Values For Some Two-Phase Induction Motors

Motor	Inertia, oz in. sec²	Maximum Torque, oz in.	Torque/Inertia Ratio, radians/sec²	Maximum Speed, rpm
Fig. 1 (A)	2.84×10^{-5}	0.28	10,000	5,500
Fig. 1 (B)	3.8×10^{-5}	2.7	46,000	7,200
Fig. 1 (C)	3.64×10^{-3}	14	3,750	3,700

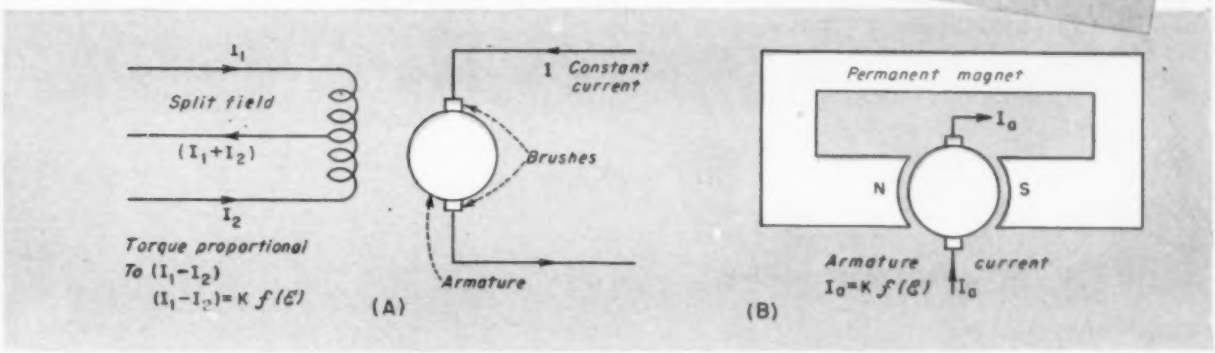

Fig. 3—Direct current servomotors.—(A) Split field construction. These motors can be driven by vacuum tube or magnetic amplifiers.—(B) Permanent magnet field construction. These can be driven from relays, thyratons and magnetic amplifiers.

Permanent magnet field construction.

In the split-field type, Fig. 3 (A) the armature is supplied from a constant current source and the motor speed is controlled by the differential field current. These motors can be driven by vacuum tube amplifiers or magnetic amplifiers. They range in size from a few to more than 100 watts. The rate of response becomes slower as the size increases.

In the permanent magnet field type, Fig. 3 (B), field strength is constant and speed is controlled by varying the current in the armature.

Permanent magnet field d-c motors are driven from relays, thyratrons, and magnetic amplifiers. In general, the high-curent low-voltage ratings of these motors prevent the use of vacuum tube drive circuits. The construction of high impedance armature windings is hampered by problems of wire size and breakdown of the brushes under high voltages.

Since the development of permanent magnet d-c motors is recent, they are most often designed for individual applications. Some standard units ranging in size from 20 to 100 watts output, however, are available.

The combination of high curent capacity relays, working from low voltage d-c power sources, and permanent magnet d-c motors makes possible high performance servomechanisms of small overall size having outputs from 10 to 30 watts.

One disadvantage in d-c servomotors is brush life. Commutation requirements for servomotors are severe. They may be required to perform under large variations in altitude, temperature, speed and load torque. Operational reliability under such conditions is limited by brush life. Furthermore, a high level of brush friction can put a serious deadspace into the motor operation.

When short life can be tolerated, a higher output can be obtained for a given volume from a d-c motor than an a-c motor. This is particularly true of the permanent magnet motor.

MAGNETIC CLUTCHES. These devices vary the coupling torque between two shafts by varying the magnetic state of a magnetic medium located between the input and output shafts, Fig. 4. These clutches are suitable for the intermediate servomoter sizes, 25 watts to 1 hp output. In Fig. 5 is shown a ½ hp servodrive that incorporates a magnetic particle clutch. This assembly was designed for a special application.

Any motor can be employed as the power source for the input shaft. The output torque level of the clutch is proportional to the current in the control winding. When the load torque is less than the torque level of the clutch, the input and output shafts rotate at the same speed. When the load torque is greater than the torque level of the clutch, slipping occurs and the output shaft rotates slower than the input shaft.

The amount of heat generated when slipping depends upon the difference in shaft speeds and the torque level of the clutch. The heat dissipating rate of the clutch, of course, should be sufficient to dissipate the heat generated by slipping in a duty cycle.

Bidirectional output rotation can be obtained by employing a pair of magnetic clutches as shown in Fig. 6. The residual magnetism of the clutch keeps the gear train loaded in the same direction at all times, thus giving the effect of a spring loaded gear train having no backlash.

The advantages of the magnetic clutch include small size for the power controlled, fast response, high power

Fig. 4—Magnetic clutch varies the coupling torque between the input and output shafts.

Fig. 5—Servodrive, which is rated a ¼ hp, that contains a magnetic particle clutch.

Fig. 6—Pair of magnetic clutches as employed to obtain bidirectional output rotation.

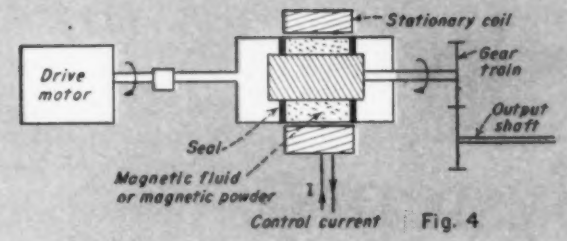

Fig. 4

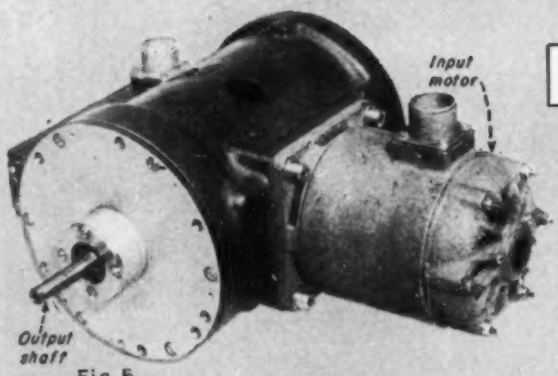

Fig. 5

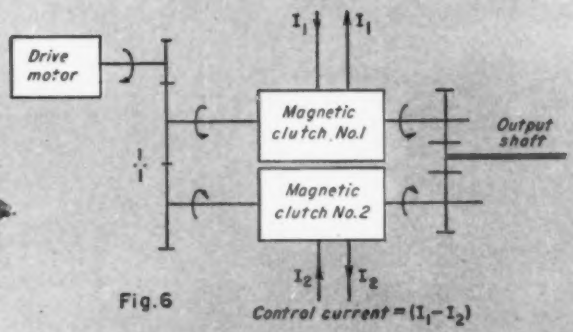

Fig. 6

gain, and smooth action. The disadvantages include heating when the duty cycle calls for long periods of operation at high values of slip, possibility of clutch material getting into the bearings, wear of clutch surfaces, and nonlinear response to rapid variation of input signal.

HYSTERESIS CLUTCHES. These clutches employ no magnetic coupling medium, but depend for their action on the magnetic state of the iron in their input and output members.

The permanent magnet clutch is somewhat slower in response than the magnetic types, but because of its endurance and reliability the permanent magnet clutch has an important position in servomechanism applications.

MOTOR-GENERATOR ELECTRIC SYSTEMS. The basic principles of the functioning of one system are shown in Fig. 7. The prime power source is generally an electric motor. This motor drives a generator the field of which is controlled by some electronic means. As the field current is varied, the voltage output of the generator is varied and thus drives the output motor at varying speed. In another system, a special connection of the generator increases the gain of this unit and thus permits the control of high power output levels with comparatively small control signals.

While these systems are relatively large, they are capable of rapid response, and have a high degree of reliability and long life.

HYDRAULIC MOTOR. In this type of servomechanism drive, a piston type hydraulic motor or a ram is supplied with oil under high pressure delivered at a controlled variable volume. In some arrangements, the motor or ram is supplied directly from a variable displacement pump. Another arrangement is to meter a high pressure supply to the motor or ram by means of a variable displacement piston and cylinder combination of one or two stages as shown in Fig. 8. The construction of these pumps and piston-cylinder combinations is such that the amount of their stroke displacement is controlled by solenoids or torquemotors. These in turn are readily matched to an electronic amplifier. It is not uncommon to control a 6 hp hydraulic motor with a torquemotor receiving only one watt of control power. The single stage 3 hp hydraulic ram shown in Fig. 9 is controlled with 2 watts of electrical power.

The piston type hydraulic motor is most frequently applied when rotary output motion is desired, while the ram is gaining increased acceptance in applications calling for linear motion. The ram effectively eliminates the more expensive and complex gearing required to go from the high speed rotary motion of the piston type hydraulic motor to the low speed linear output motion.

When the effect of oil compressibility is minimized by using a short pipe line between the source of pressure supply and the hydraulic motor, the response of the system is extremely fast. Often the motor is capable of producing accelerations greater than 100,000 radians per sec per sec with a bandwidth in excess of 25 cycles per second.

The hydraulic motor is small in size and has a fast response and a high power gain. Auxiliary equipment such as pumps, lines, filters, accumulators, and valving, however, are necessary.

Selection of Gear Ratio

Having selected the type of motor that best suits the application, the next step is to decide upon a motor having characteristics that will adequately perform the work required, and then to match the motor to its load with a suitable gear train.

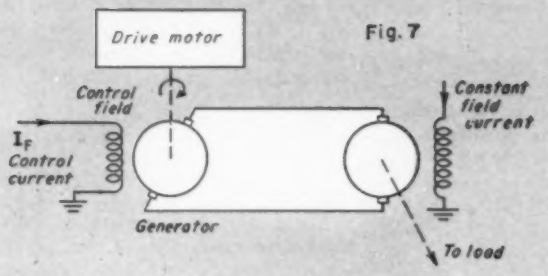

Fig. 7

Fig. 7—In this motor-generator set, varying the generator field current varies the voltage output of the generator and thus varies the speed of the output motor.

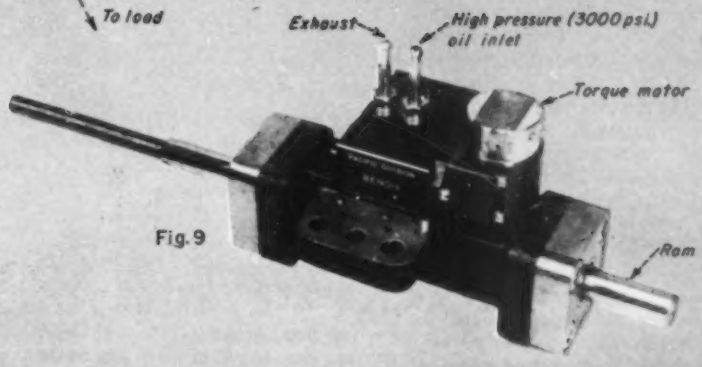

Fig. 9

Fig. 9—A single stage 3 hp hydraulic ram that is controlled with 2 watts of electrical power.

Fig. 8—Variable displacement piston and cylinder combinations for metering oil supply. (A) Single stage, shown in zero output position. (B) Two stage; pilot piston meters oil to power piston. Power piston in turn meters oil at a higher rate to hydraulic motor or ram.

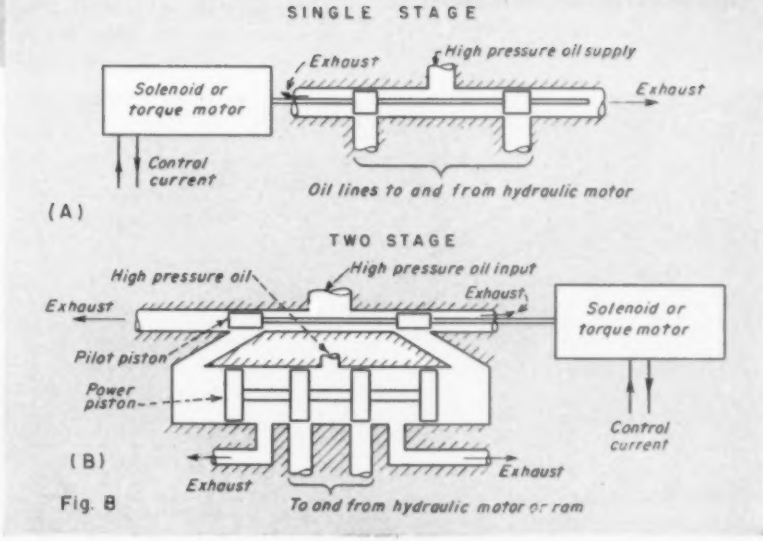

Fig. 8

It is assumed that the following characteristics of the motor and the load are known:

1. Motor inertia.
2. Torque-speed characteristic of the motor under maximum input conditions. This information can generally be obtained from the manufacturer of the motor.
3. Load inertia.
4. Required load acceleration capability as a function of load speed. This information is generally given as part of the servomechanism specification or can be deduced from it.

Where

J_l = moment of inertia of load about load axis, oz in. sec²
J_m = moment of inertia of motor about its axis, oz in. sec²
A_l = load acceleration, rad/sec²
T_l = load torque, such as work performed and friction at the output, oz in.
T_m = motor torque, oz in.
G = gear ratio, that is, ratio of motor shaft speed to load shaft speed.

It is evident that during acceleration the relation between the motor load and the output load is:

$$J_m A_l G^3 - T_m G + J_l A_l + T_l = 0 \quad (1)$$

To meet the conditions of Eq (1), the gear ratio G has a real value only when

$$(T_m^2/J_m) \geq 4A_l (J_l A_l + T_l) \quad (2)$$

The left hand term of Eq (2) may be considered a Figure of Merit for the motor. The right hand term represents an Acceleration Load.

In applying Eq (2) to determine whether or not a motor can meet the acceleration requirements of the load, care must be taken to evaluate the Acceleration Load and the Figure of Merit under approximately equivalent speed conditions and at the speed where the motor experiences the greatest difficulty in accelerating the load to the degree required.

After a suitable motor has been selected to meet the acceleration requirements, it is necessary to determine whether the range of acceptable gear ratios gives the desired range of output speed.

By defining K_a to be an Acceptability Factor equal to the ratio of the Figure of Merit to the Acceleration Load, and substituting K_a in Eq (1), the value of the range an acceptable gear ratio is

$$G = \frac{T_m}{2J_m A_l}\left[1 \pm \sqrt{\frac{K_a - 1}{K_a}}\right] \quad (3)$$

Note that K_a must be greater than

unity for the motor to meet the acceleration specification.

In the foregoing analysis, the effect of the gear train inertia has been neglected. This effect, may often be a dominant factor in overall response.

A precise evaluation of the effect of gear train inertia generally is too complex and time consuming to consider in the preliminary analysis. Most applications are such that the dimensions of the gears immediately following the motor shaft are determined by practical limitations rather than by the overall gear ratio. Since these gears contribute the predominant portion of the gear train inertia as referred to the motor shaft, satisfactory preliminary results are obtained by including in the motor inertia an estimated approximate value of the inertia of these gears.

As it becomes clearer just which size motor will suffice, the approximations can be made again more exactly to arrive at a rapidly converging design.

Finally the torque-speed curve of the motor should be converted into an acceleration-speed curve of the output. A procedure is as follows.

Define a Matching Factor K_m as

$$K_m = G\sqrt{J_m/J_l} \qquad (4)$$

Substituting Eq (4) in Eq (1) and solving for the acceleration A_l gives

$$A_l = \frac{T_m K_m}{\sqrt{J_l J_m}\,(K_m^2+1)} - \frac{T_l}{J_l\,(K_m^2+1)} \qquad (5)$$

Thus to convert a torque ordinate on the motor performance curve to an output acceleration A_l, the torque T_m is multiplied by

$$K_m/\sqrt{J_l J_m}\,(K_m^2+1) \qquad (5A)$$

and from the quantity $(5A)$ is subtracted

$$T_l/J_l\,(K_m^2+1) \qquad (5B)$$

Since the quantity $(5B)$ is constant, its subtraction from the quantity $(5A)$ moves the curve for quantity $(5A)$ down by a constant amount.

The motor speed abscissa, of course, is multiplied by $1/G$ to obtain the speed of the output shaft.

This procedure results, as shown in Fig. 10, in a curve that relates load acceleration capability with load speeds. Repetition of this procedure for a few values of gear ratio and refined approximations of gear train inertia should indicate the gear ratio that gives the most desirable relation between acceleration and speed output.

EXAMPLE OF DESIGN PROCEDURE. Consider the problem of driving the arm of the plotting table shown schematically in Fig. 11. The arm weighs 9 lb and is driven by a metal belt running over a 2.5 in. dia pulley.

The inertia load is therefore

$$J_l = \frac{9\times16\times(2.5/2)^2}{32.16\times12} = 0.584 \text{ oz in. sec}^2$$

The output arm acceleration capability must exceed 100 in. per sec per sec at all speeds from 0 to 18 in. per sec. For the maximum condition

$A_l = 100/(2.5/2) = 80$ radians per sec^2

The maximum friction load is 10 oz, or

$T_l = 10 \times 1.25 = 12.5$ in. oz.

The Acceleration Load is

$4A_l\,(J_lA_l + T_l)$ or

$4\times80\,[0.584\times80+12.5] = 18{,}950$ in. oz/sec^2

Based on previous experience the gear train inertia is estimated as:

$J_G = 0.07/386 = 1.8\times10^{-4}$ in. oz sec^2

The next step is to select a motor having a Figure of Merit that is equal to or greater than the Acceleration Load. In the process of selection, consider a CK-2000-1A two-phase induction motor, the torque—speed curves of which are given in Fig. 12 for a reference field excitation of 64 volts. From these curves, for a speed of 4,000 rpm and for a control field of 64 volts, the motor torque is

$$T_m = 1.75 \text{ in. oz}$$

Therefore:

$$\frac{T_m^2}{J_m} = \frac{1.75^2}{2.2\times10^{-4}} = 14{,}000 \text{ in. oz/sec}^2$$

This Figure of Merit, even without

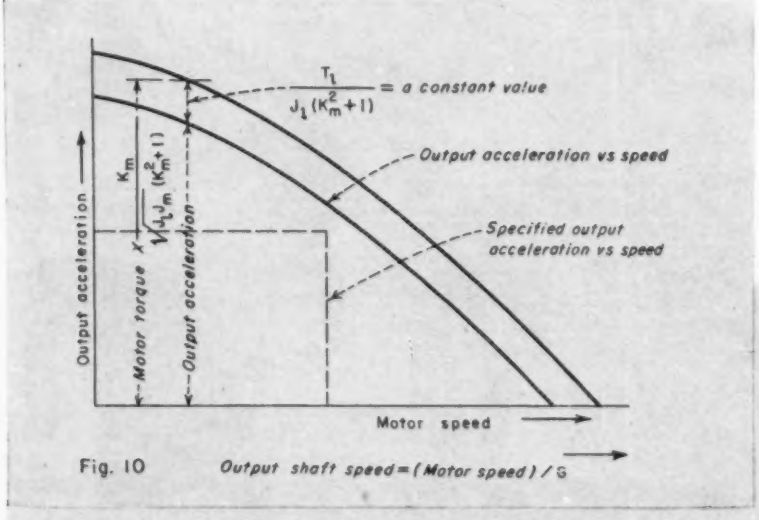

Fig. 10

Fig. 10—Graphical design procedure in relating load acceleration capability with load speeds.

Fig. 11—Example to demonstrate design procedure in the selection of motor and gear ratio for driving the arm of a plotting table.

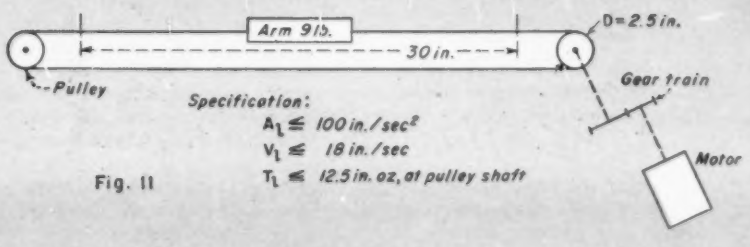

Fig. 11

Fig. 12—Torque-speed curves for a CK-2000-1A two-phase induction motor. Moment of inertia of motor is 2.2×10^{-4} oz in. sec.^{2} Curves are for a reference field excitation of 64 volts.

Fig. 13—Torque-speed curves for a CK-3000-1A modified two-phase induction motor whose moment of inertia is 3.6×10^{-4} oz. in sec.^{2} Reference field excitation is 110 volts.

considering the gear train, is less than the Acceleration Load (18,950 oz in./sec^2). The CK 2000-1A motor, therefore, is not adequate to drive the table arm.

Next investigate the suitability of a CK-3000-1A modified motor, the torque speed curves of which are given in Fig. 13 for a reference field excitation of 110 volts. From these curves, for a motor speed of 2,000 rpm and for a control field excitation of 240 volts, the motor torque is

$$T_m = 14 \text{ oz in.}$$

therefore, the Figure of Merit for this motor, without the gear train, at the stated conditions is

$$\frac{T_m^2}{J_m} = \frac{14^2}{3.6 \times 10^{-3}} = 54{,}444$$

Thus the modified CK-3000-1A motor will drive the load with an acceptability factor of

$$K_a = 54{,}444/18{,}950 = 2.87$$

Since the estimated gear train inertia is 5 percent of the moment of inertia of the motor, the Acceptability Factor when modified to include the gear train becomes

$$K_a = 2.87/(1 + 0.05) = 2.74$$

From Eq (3), the range of usable gear ratios is

$$G = \frac{14}{2\times(3.6\times10^{-3}+1.8\times10^{-4})\times80}\left[1 \pm \sqrt{\frac{1.74}{2.74}}\right] = 4.7 \text{ to } 41.6$$

For a motor speed of 2000 rpm and an arm velocity of 18 in. per sec, a gear ratio of 14.6 is required. In the interest of simplicity of design and construction, a gear ratio of 16 to 1 will be chosen.

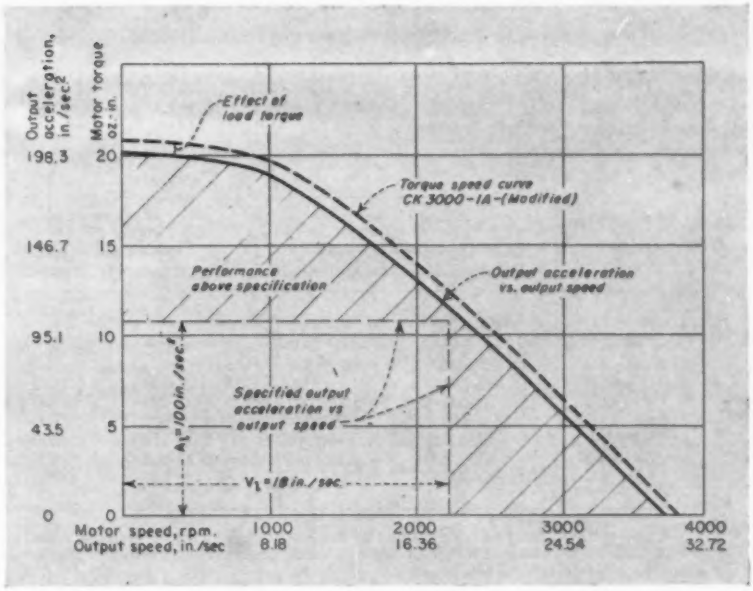

Fig. 14—Output acceleration and output speed curve for selected motor and gear train.

For this gear ratio, factor K_m is

$$K_m = G\sqrt{(J_m + J_G)/J_l} = 16\sqrt{(3.6\times10^{-3}+1.8\times10^{-4})/0.584} = 1.28$$

To check graphically the capacity of the selected motor and gear train to deliver the required output acceleration over the required range of output speed, construct a diagram like that shown in Fig. 14. The ordinates of the shaded portion of this diagram are units of output acceleration. These ordinates are obtained by multiplying the ordinates of the motor torque-speed curve, at 240 control field voltage, of Fig. 13 for each speed by

$$\frac{K_m}{\sqrt{J_l(J_m + J_G)(K)_m^2 + 1)}} = 10.32$$

and subtracting from each of these products the quantity

$$\frac{T_l}{J_l(K_m^2+1)} = \frac{12.5}{0.584\ (1.28^2+1)} = 8.1$$

It is evident from Fig. 14 that the selected motor and gear train will fulfill the specifications of the problem.

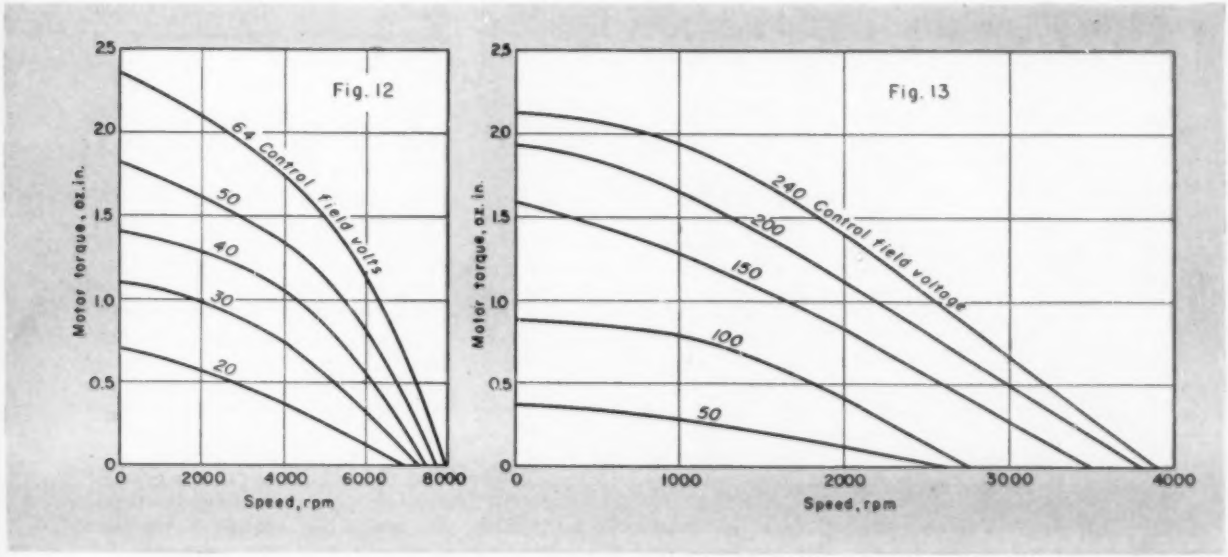

Table I—Guide for Selection of Lubricating Oils for Plain Bearings

Speed, rpm	Viscosity in SSU @ 100 F					
	Light Load Up to 100 psi *Application Method		Medium Load 100 to 250 psi Application Method		Heavy Load Above 250 psi Application Method	
	Continuous	Once-through	Continuous	Once-through	Continuous	Once-through
5,000–10,000	40–65	65–85	–	–	–	–
3,500–5,000	65–85	85–100	–	–	–	–
2,000–3,500	85–100	100–150	–	–	–	–
1,000–2,000	100–150	150–300	150–300	300–500	–	–
500–1,000	150–300	300–500	300–500	500–800	–	–
300–500	300–500	500–800	500–800	800–1,200	–	–
100–300	500–800	800–1,200	800–1,200	1,200–1,800	1,750–3,000	2,400–7,000
50–100	800–1,200	1,200–1,800	1,200–1,800	1,800–2,600	1,750–3,000	2,400–7,000
Under 50	1,200–1,800	1,800–2,600	1,800–2,600	2,300–3,300	2,400–7,000	2,400–7,000

These recommendations are specific to plain bearings operating under uniform load conditions at operating temperatures between 60 F and 140 F. Where extreme or intermittent shock loading exists, extreme pressure high film strength type oils of comparable viscosity should be employed.

*—Continuous Application Methods provide a constant flow of oil to the bearings and include ring oilers, collar oilers, circulating systems, mist or fog lubricators, bath or splash systems.

Once-through Application Methods provide intermittent amounts of oil to the bearings and include bottle oilers, wick-feed oilers, drop-feed oilers, mechanical force-feed oilers and oil cams.

Selecting the Right Plain Bearing Lubricant

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IN SELECTING the proper lubricant for a plain bearing there are two factors to consider: the type of oil, and the viscosity of the oil. For a specific bearing application, the oil viscosity and type depend on the speed, load, type of load, temperature, and method of oil application.

Speed

The speed of the shaft is the most important variable. The lower the speed, the higher must be the oil viscosity to produce a load-supporting film. Conversely, the higher the speed, the lower must be the oil viscosity. Thus, for any given speed there is a viscosity range which will offer the most efficient lubrication. If the oil has too high a viscosity it will be too heavy to form the proper wedge between the journal and the bearing. This is particularly true where once-through methods of application, such as a drop-feed oiler, are used. High viscosity may also cause overheating of the bearing because of fluid friction. This condition is more likely to occur under continuous flow methods of lubrication.

If the viscosity is too low, the oil film will not be thick enough to prevent metal to metal contact and wear of bearings and journals will take place. This condition occurs in the lower speed range or where the surface finish is rough.

Side-leakage is also a factor. To form and maintain a complete oil film, a sufficient quantity of oil of the correct viscosity must be delivered to the bearing to compensate for any loss through side-leakage. In many cases, this consideration will determine whether or not a plain bearing is operating under thick film or boundary lubrication conditions.

Load

It is generally accepted that the heavier oils have higher load-carrying ability than the lighter, less viscous oils. In practice, the heavier the load, the higher the required viscosity; conversely, the lighter the load, the lower the required viscosity. Here again, there is a viscosity range within which the highest efficiency will be obtained.

In a given application, if it is known that the unit pressure on the bearing is so large that straight mineral oils will not have sufficient film strength or load-carrying ability to prevent metal-to-metal contact, then compounded or extreme pressure oils having high oiliness characteristics should be used. For equivalent viscosities these oils will carry a heavier load.

Type of Load

Most plain bearings operate under uniform load conditions. However, in some applications the loading fluctuates. Shock loading, intermittent loading and reversals of load all cause special lubricating problems. Many plain bearings used in conjunction with gears are shock loaded or "hammered" by the sudden application of heavy loads. In this case compounded or extreme pressure high-film-strength oils are used; preferably in the viscosity range suitable for the specific speed conditions.

Reversal in loading is a condition where the direction of rotation of the journal is suddenly reversed or where the load is applied in more than one direction. When a journal is reversed during operation, an oil wedge must be present on both sides of the journal to accommodate an adequate film. Continuous flow of straight mineral type oil under pressure gives adequate lubrication to reduce metal wear in such applications, unless very heavy or shock loading accompanies such reversal.

Temperature

The normal operating temperature range of industrial plain bearings is between 60 F and 140 F. Plain bearings operating below or above this range require special consideration in determining the proper lubricant.

As temperature is increased, the viscosity of any mineral oil decreases. If the viscosity decreases to a point where the film thickness between the journal and the bearing is too thin, boundary lubrication results. Under boundary (thin film) conditions there is an increase in sliding friction, a resultant increase in temperature, and greater wear. To alleviate this condition either a heavier oil or an oil having higher oiliness and higher film strength is used. If the oil has a low viscosity index, the situation can sometimes be corrected by using an oil having a higher index. As the temperature is increased, oils of high viscosity index do not thin out as rapidly as do low viscosity index oils.

Bearing oil temperature should be kept below 140 F if possible, since the rate of oil deterioration doubles for about every 18 F temperature rise. Therefore, special cooling equipment may be desirable on systems using plain bearings with continuous methods of lubricant application. When plain bearings are operating above 140 F and are lubricated by once-through methods of application, straight mineral oils of proper viscosity give satisfactory results. Where a continuous method such as a circulating system is used, high quality oils containing oxidation inhibitors are the most satisfactory.

Method of Application

There are two types of lubricant application: continuous and once-through. Continuous application methods provide a constant flow of oil to the bearings and include ring oilers, collar oilers, circulating systems, mist or fog lubricators, and bath or splash systems. Once-through methods provide intermittent amounts of oil to the bearings. These include bottle oilers, wick-feed oilers, mechanical force-feed oilers, drop-feed oilers and oil cans.

Bearings lubricated by a continuous method derive the benefit of the cooling effect of the oil and are generally more dependable. Lighter viscosity oils may be used in continuous application systems than those applied to bearings by the once-through type applicators. In continuous systems, the same oil is used over and over again with an economy in lower oil use and labor costs. These savings generally more than offset the higher cost per gallon of the better quality oils required in continuous systems.

Under a specific set of speed and load conditions, slightly higher viscosity oils are used for once-through methods than continuous methods of application. This compensates for the lack of a steady supply of oil. The heavier grade is necessary to maintain the proper film thickness until the next droplet is supplied to the bearing. Then again, bearings operating under once-through methods generally run hotter and a heavier oil is required because of the lower viscosity and high end-leakage.

The affect of these five variables on the selection of an oil of the proper viscosity is shown in Table I. In this table the bearings are assumed to be operating at a temperature between 60 F and 140 F under uniform load conditions.

As an example, the proper viscosity of an oil to lubricate a plain bearing operating at a temperature of 120 F, a speed of 750 rpm, a unit pressure of less than 100 psi, mechanical force-feed application, and with uniform loading is determined as follows. Follow the speed column down to 500-1,000 rpm. Then cross horizontally to the third column under light load and once-through application. The correct viscosity range is 300-500 SSU at 100 F. From the previous discussion, a good grade of straight mineral oil in this viscosity range should be satisfactory.

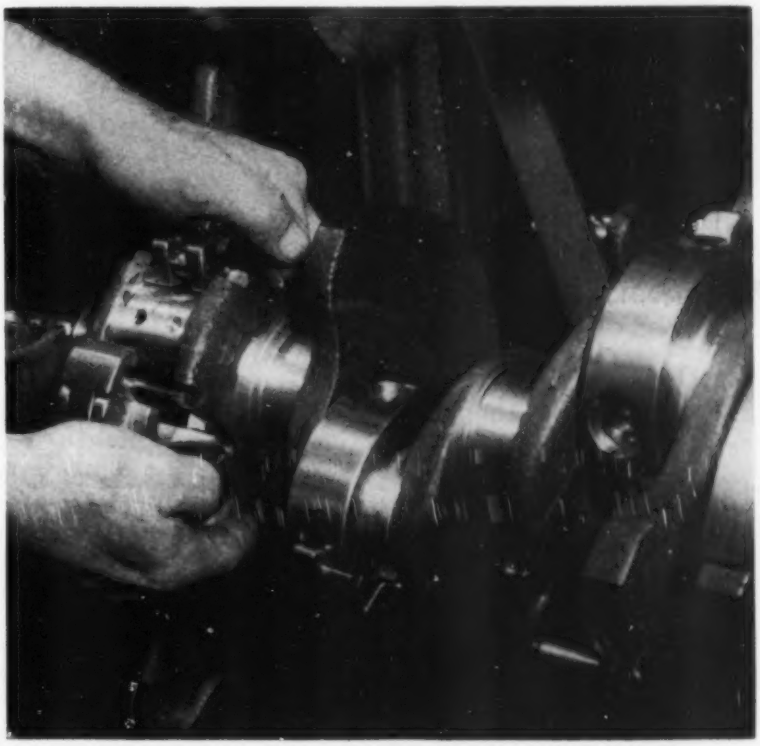
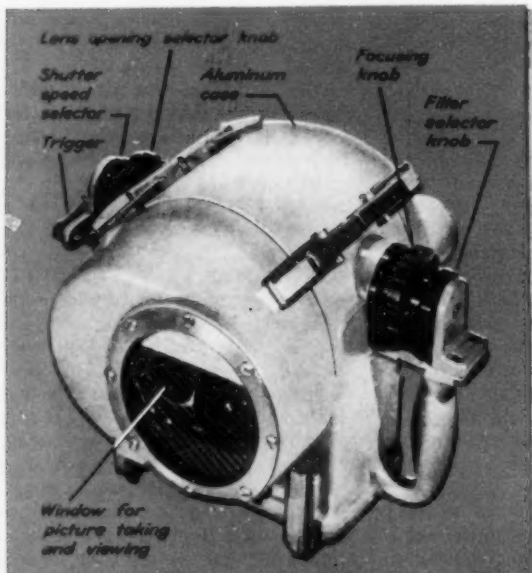
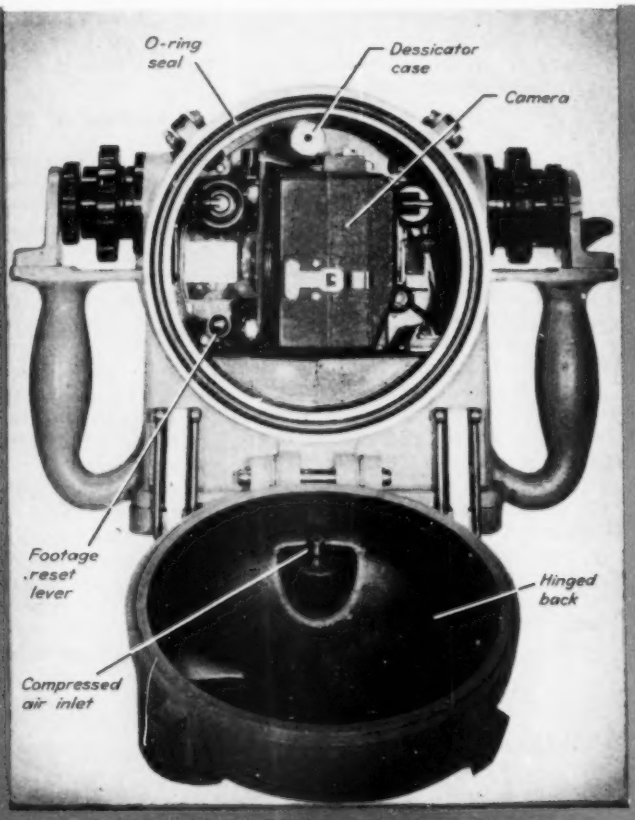


Fig. 1—Crankshaft bearings with combination circulating and splash feed system.



UNDERWATER motion picture camera uses anodized aluminum outer case for lightness, and because it attracts condensation and keeps glass surfaces dry. Camera weighs 22 lb in air, but only 3¼ lb under water. All controls are brought outside of camera for easy operation through V-ring packing seals. Additional accessory flotation blocks are attached to the camera for sustained periods of underwater photography. These overcome the camera's slight tendency to sink because of the weight.



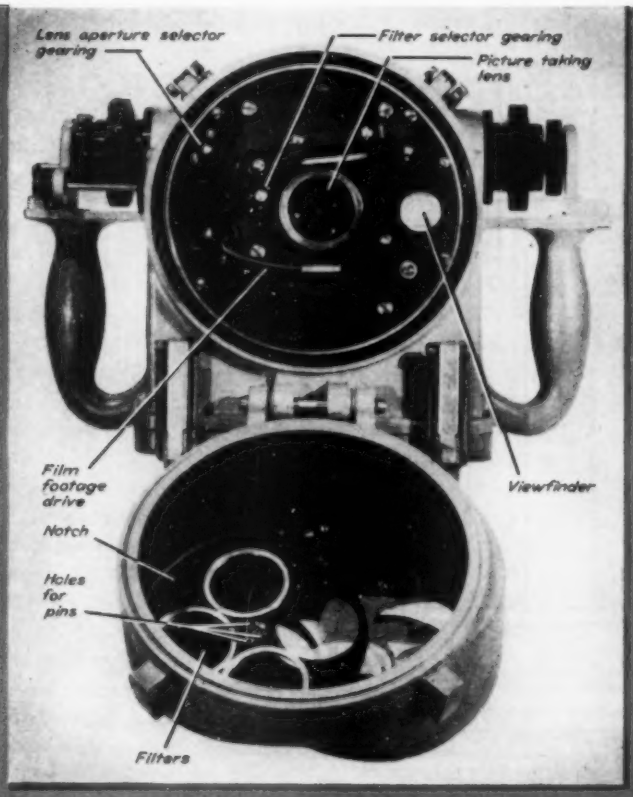
REAR VIEW of camera shows how back swings down to load film in magazine. O-ring provides watertight seal; compressed air pressurizes camera as a safeguard and escaping air bubbles warn operator if there is foreign material under the seal that might cause a leak. Dessicator absorbs water vapor to reduce condensation when camera is immersed in cold water.

Outside Controls in Lightweight

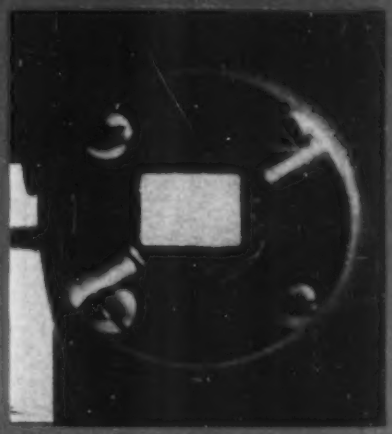
Ingenious use of V-ring packings and gear trains allows the Fenjohn Co. Ardmore, Penna., to bring all controls outside of the water tight case of a light-weight, electrically operated, 16mm motion picture camera. With this arrangement, the photographer can focus, and change lens aperture, shutter speed, and filters underwater. The anodized aluminum case reduces weight to 22 lb compared to over 100 lb for conventional underwater cameras.

Fenjohn uses a standard 16mm Bell and Howell camera to which they have added three additional speeds. These speeds were gained by adding an auxiliary spring to the fly ball, two weight governor so that it would operate at either of two conditions. As a result, each of the three standard gear trains is capable of two different speeds. Modification to obtain this involved cutting two detents 60 deg. apart on the triple cam which actuates the engagement of the variable tumbler gears. When the connecting rod from the governor mechanism lies in a detent, the governor permits three new speeds; when the connecting rod lies on the cam surface, the governor permits the three original speeds. Eighteen 1½v dry cells power the motor.

Simple hasps are used so the camera can be opened for film reloading without special tools. Body parts are sealed by O-rings. Tested in depths up to 245 ft with-

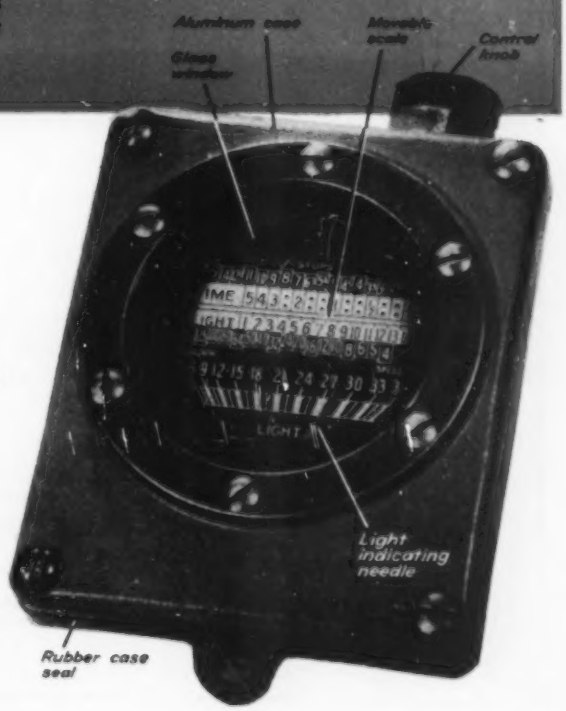


FRONT CASE of camera contains built-in filter holder that can be moved into place by an outside-camera-control. Pins on filter selector gear fit into filter holder in only one position. Flexible cable from the motor drives the footage counter. Lens aperture is simple gear train and all of the brass gears are blackened to cut down light reflection.



(ABOVE) Operator looking through view finder can see not only what he is photographing but also lens aperture and footage being used. Indicator light shows camera in action.

(BELOW) Underwater exposure meter in sealed aluminum case has glass windows. Control Knob to move scale is pinned into similar knob on meter and V-ring packing seals out water.

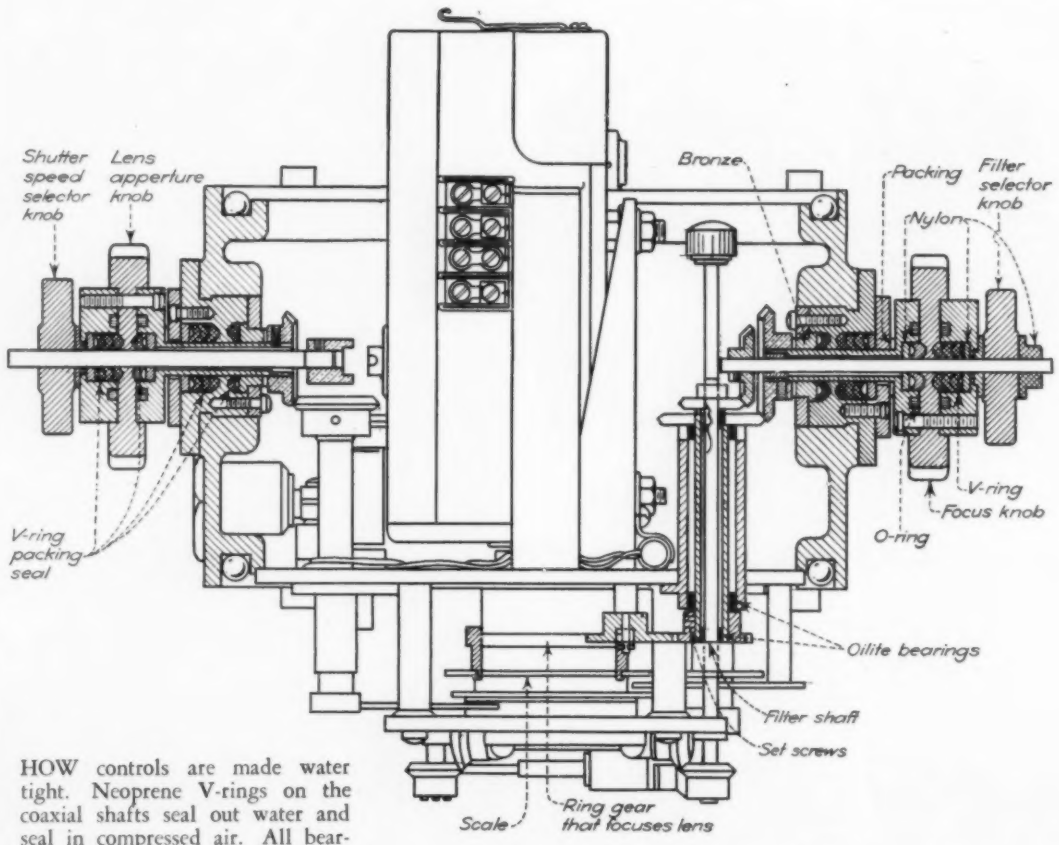


Underwater Camera

out leaking, the camera requires internal pressurization only when used at depths in excess of 100 ft. Pressurization at other depths is useful to indicate if dirt particles are interfering with O-ring sealing.

Designed by the Fenjohn Company with special engineering by the Barnes Development Company, Lansdowne, Penna., the camera also has above-water uses. Because the aluminum case protects the camera mechanism from shock and debris, the camera can be used to photograph destructive tests and explosions when standard photographic equipment might be damaged. The Photographic Instrumentation Division of J. A. Maurier, Inc., Long Island City, N. Y. distributes the camera.

Underwater Camera (continued)

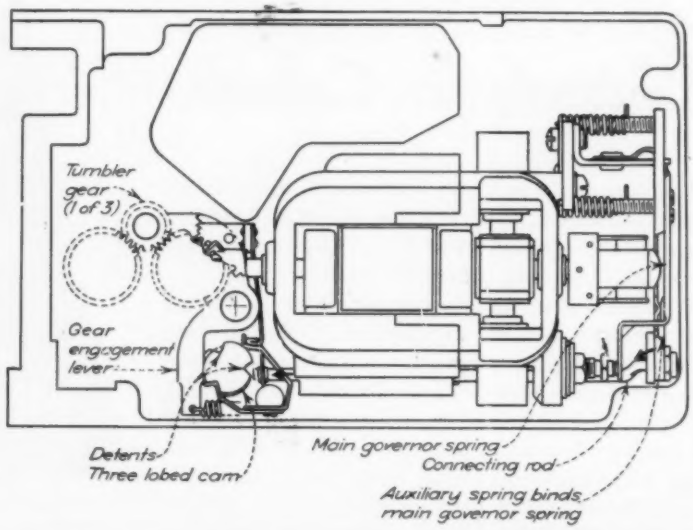


HOW controls are made water tight. Neoprene V-rings on the coaxial shafts seal out water and seal in compressed air. All bearings on the shafts are made of nylon for improved resistance to corrosion, except the inside bearing which is made of bronze for added strength.

SPEED CONTROL MECHANISM. Detents spaced 60 deg apart permit three additional speeds. Triple cams with lobes 120 deg. apart control engagement of the proper gear. In detent, connecting rod pulls auxiliary spring away from main governor spring and changes characteristics of governor.

RIGHT HAND SIDE. Filter selector knob is knurled to inner shaft so that rotations of knob are transmitted through small bevel gear to filter selector gearing. Focusing knob is locked to outer shaft on which large bevel gear is keyed to transmit rotation through gearing to the lens.

LEFT HAND SIDE. Shutter speed selector knob is knurled to inner shaft which goes directly to speed control mechanism in the camera body. Aperture selector knob screwed to flange on outershaft transmits rotation through a bevel gear to the ring gear on the lens.

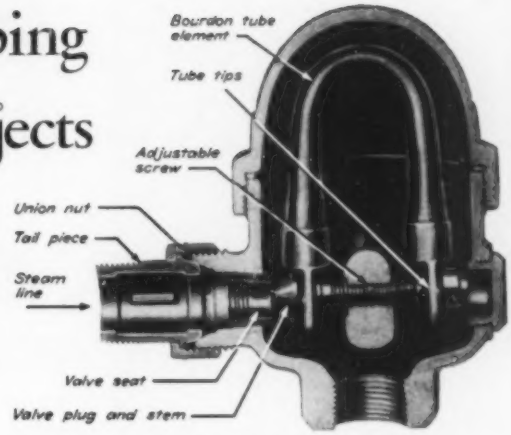


Chrome-Moly Steel Tubing Cuts Bourdon Tube Rejects

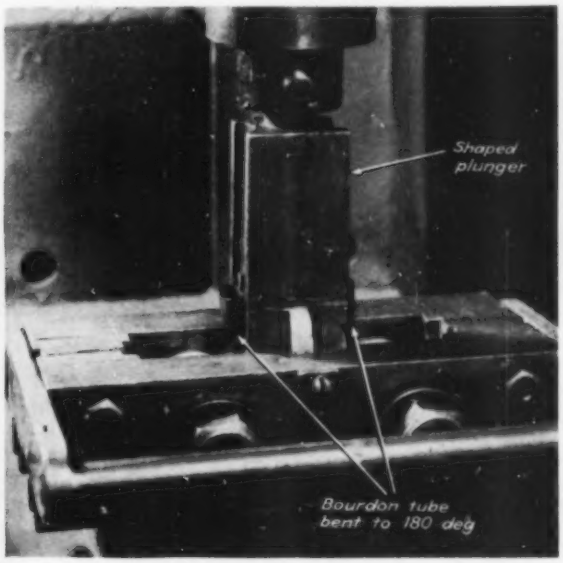
In order to reduce rejects during manufacture of Bourdon tube elements for the William S. Haines Company's "Vento" Steam Trap, metallurgists at the Superior Tube Company recommended changing the tube material from conventional alloys to AISI 4130 cchrome-molybdenum alloy steel While the design of the trap was functionally sound, the production department had to scrap large numbers of Bourdon elements because of tube fracture during bending and tip forming operations.

The metallurgists found that the combination of chromium, 0.80 to 1.10 percent, and molybdenum, 0.15 to 0.25 percent, made the alloy sufficiently ductile to withstand a 180 deg. cold-bending. And at the same time, it retained enough ductility after bending so that tube ends could be reformed to perfect roundness for tip insertion.

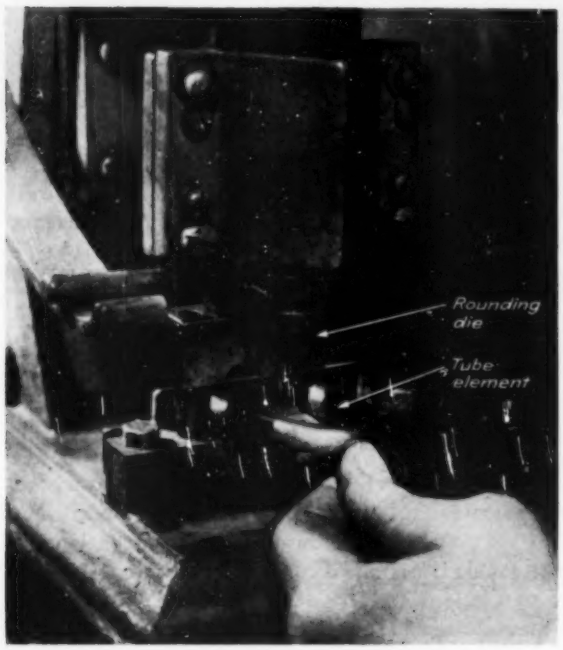
In addition, the chromium content tends to form a surface carbide that increases corrosion resistance of the element in the steam atmosphere. Silicon, 0.20 to 0.35 percent, was added to the alloy, and imparts drift and relaxation resistance to increase the length of the Bourdon element's accurate service.



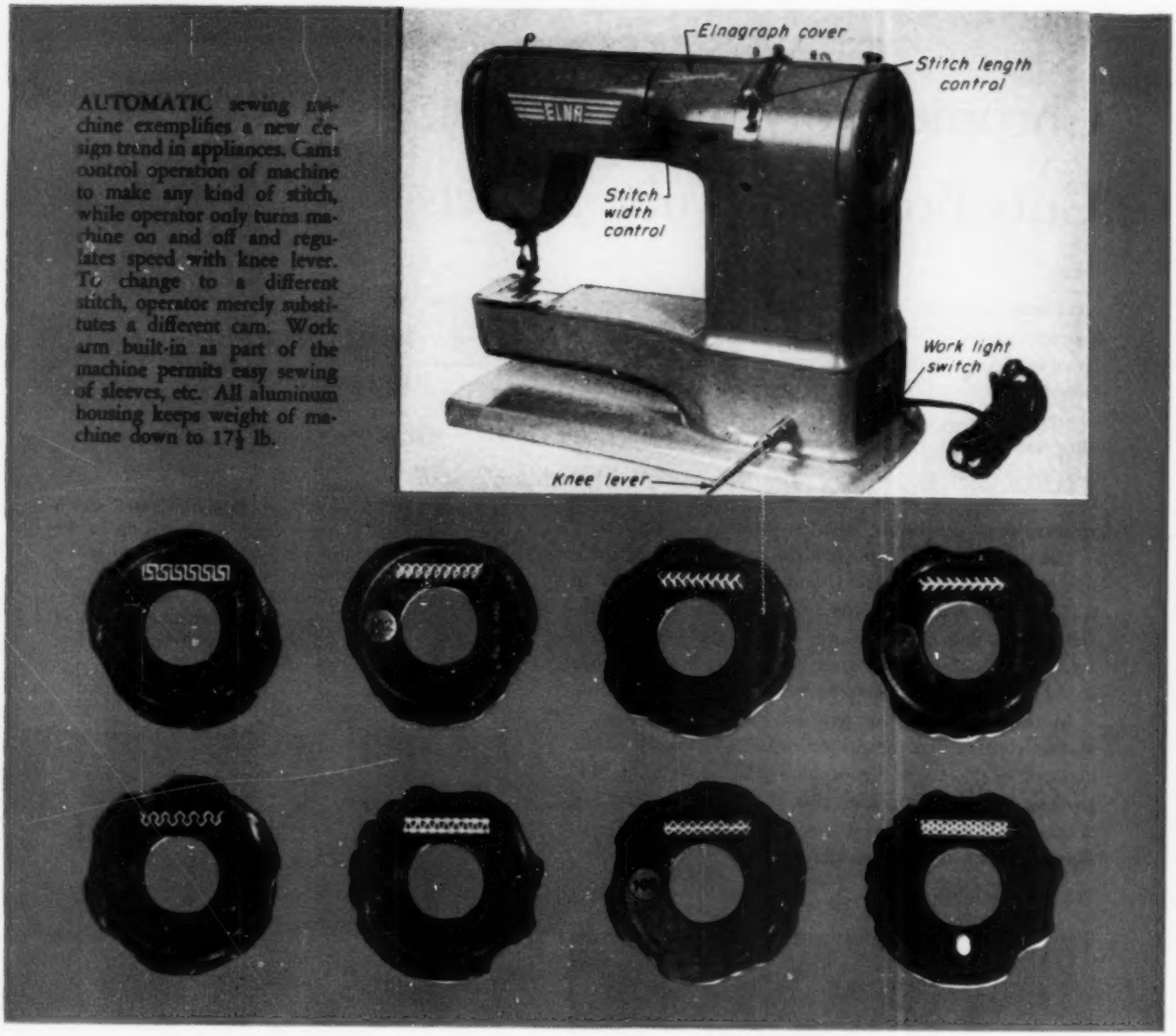
CROSS SECTION of the Haines "Vento" steam trap. During "heatup" as steam builds up in the chamber, the Bourdon element expands and forces valve plug and stem into the valve seat of the inlet valve port. This closes the trap and prevents the escape of hot steam after air and condensate have been removed from the line through plug at base of trap.



DUCTILITY of Chrome-Moly alloy permits this 180 deg. cold bending operation in the manufacture of Bourdon tube elements. To bend the alloy, shaped plunger is forced down on the tube, supported by a lead mandrel.



RESIDUAL DUCTILITY of AISI 4130 alloy permits reforming the tube to perfect roundness after the bending operation. This operation is required to permit the insertion of element tips that are held in place by crimping.



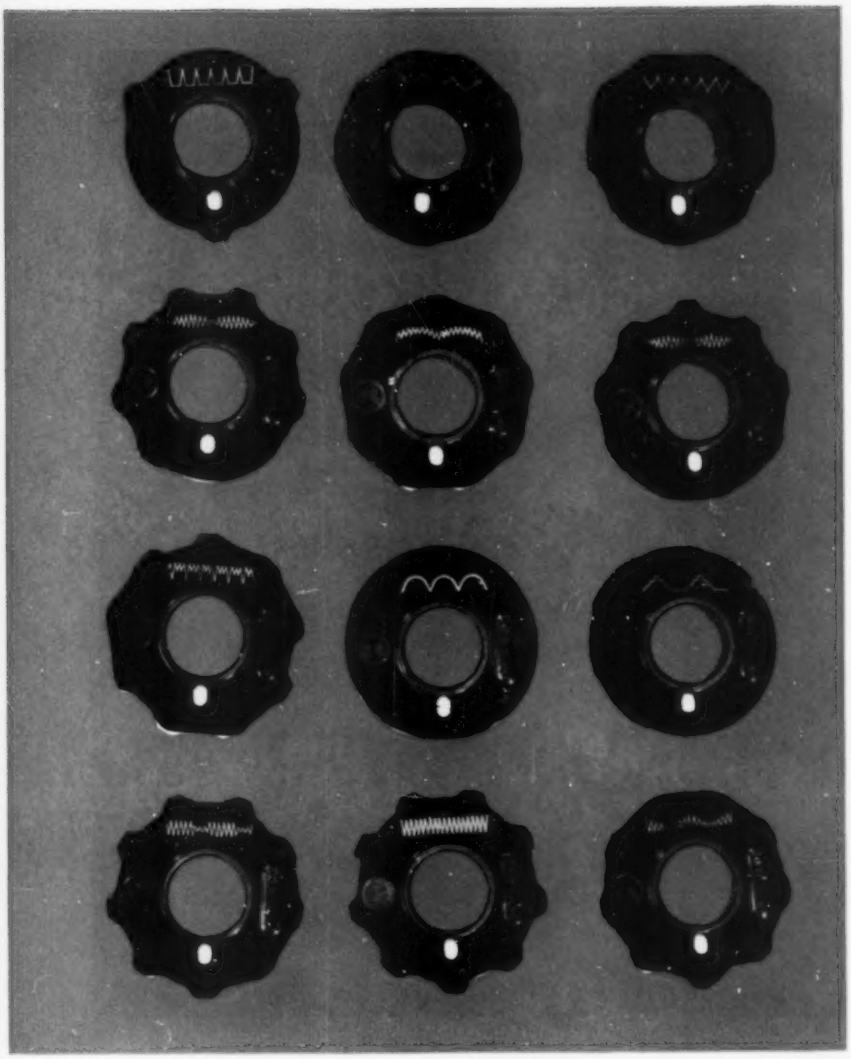
AUTOMATIC sewing machine exemplifies a new design trend in appliances. Cams control operation of machine to make any kind of stitch, while operator only turns machine on and off and regulates speed with knee lever. To change to a different stitch, operator merely substitutes a different cam. Work arm built-in as part of the machine permits easy sewing of sleeves, etc. All aluminum housing keeps weight of machine down to 17½ lb.

Plastic Cams Control Automatic Sewing Machine

Single or double disk cams control the type and length of stitch in the new Elna Portable electric zig-zag sewing machine, first automatic family machine (in a zig-zag sewing machine, the needle bar can swing horizontally and vertically; in straight-stitch machines, the needle bar is limited to vertical motion only).

When a single cam is used, the operator sets the length of stitch manually with a hand control. As the cam, driven by the motor flywheel, rotates, a follower moves the needle bar mechanism to produce the specified stitch. The double cams are actually two disk cams cut on a single blank. While the lower cam actuates the needle bar mechanism as a single cam, the upper cam continuously varies the stitch length in a predetermined manner. To change to a new stitch, the operator merely changes cams. The operator can straight stitch at any time by moving the stitch width knob pointer to the far left or zero position.

A 1/25 hp a-c d-c series-wound motor powers the Elna, with power being transmitted around-a-corner to the flywheel through a cone friction drive instead of bevel gears. An unusual cord and metal drive belt carries power from the flywheel in the upper portion of the machine to the



(LEFT) Typical cams available for a variety of sewing operations. Double cams (under machine) permit more complicated stitches than a single cam (at near left). On each cam, there is impressed a copy of the stitch it produces. There is also a number so that the housewife can look up a particular stitch in the instruction manual and determine the proper cam to use. There are over 100 phenolic cams available. Changing cams takes only a few seconds. Cams and machine are made by Tavaro S. A., Geneva, Switzerland. It is distributed in the United States by the Elna Sewing Machine Company, 164 W. 25 St., New York, N. Y.

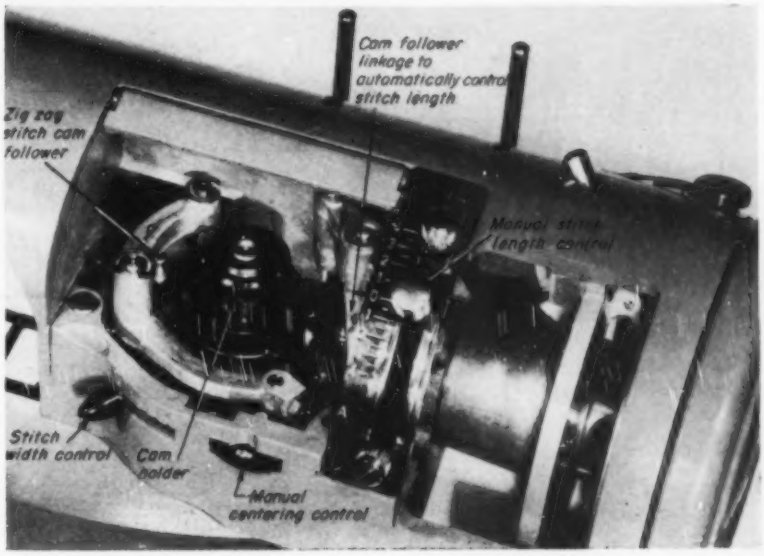
(BELOW) Elnagraph (with cover removed) is brain of automatic sewing machine. When single cams are used, left hand cam follower transmits motion to needle bar for oscillation; stitch length is set by manual control. When double cams are used, cams automatically control both stitch length, permitting rythmic variations, and needle oscillation.

There are four controls on this machine: a speed control (knee lever), an on-off light switch, stitch length control for use when single cams are used, and the stitch width control. When the latter is set on zero, machine sews conventional single stitch.

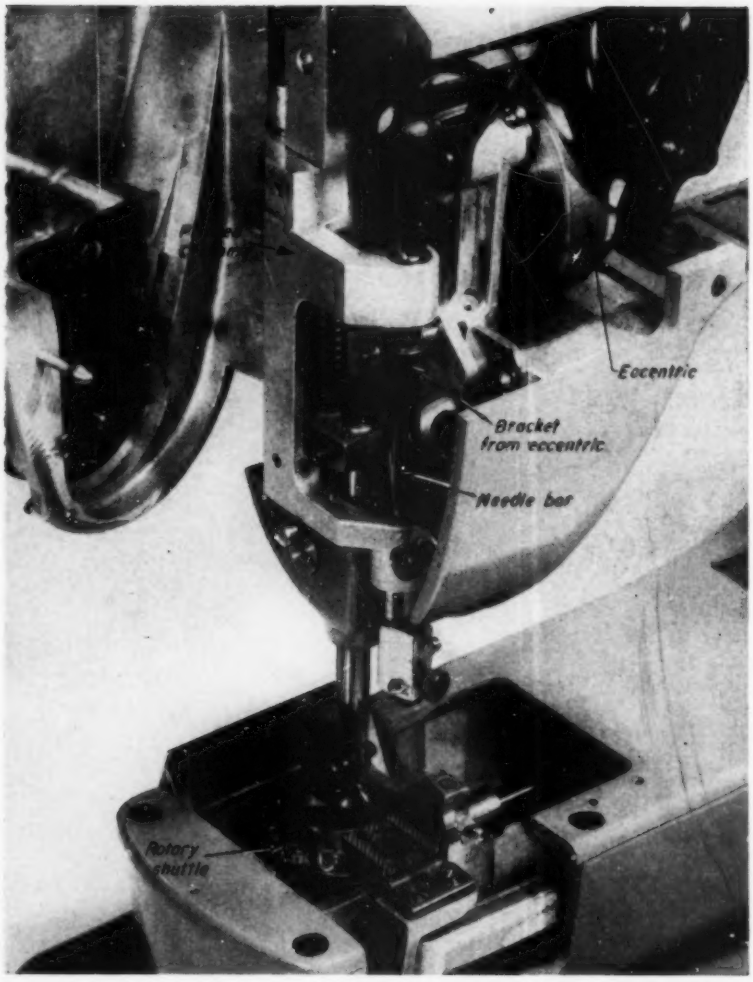
(*Continued on next page*)

rotary shuttle drive in the lower portion of the machine.

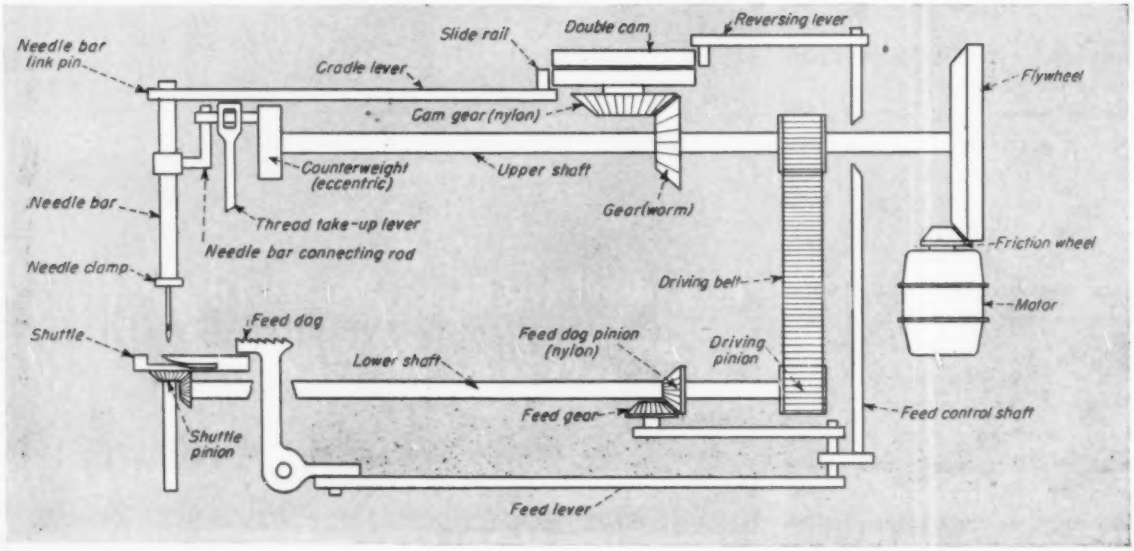
Speed control, from zero to 1,500 rpm, is maintained by operator's knee pressure on the knee lever. The control consists of a series of resistant metal strips with contact buttons. When the operator exerts slight pressure, the control arm moves to close one or two of these contacts, electrical resistance remains high, so motor speed is low. As more pressure is exerted, more contacts are closed, connecting more strips in parallel, and reducing total resistance. At full speed, all the resistance strips are connected in parallel.

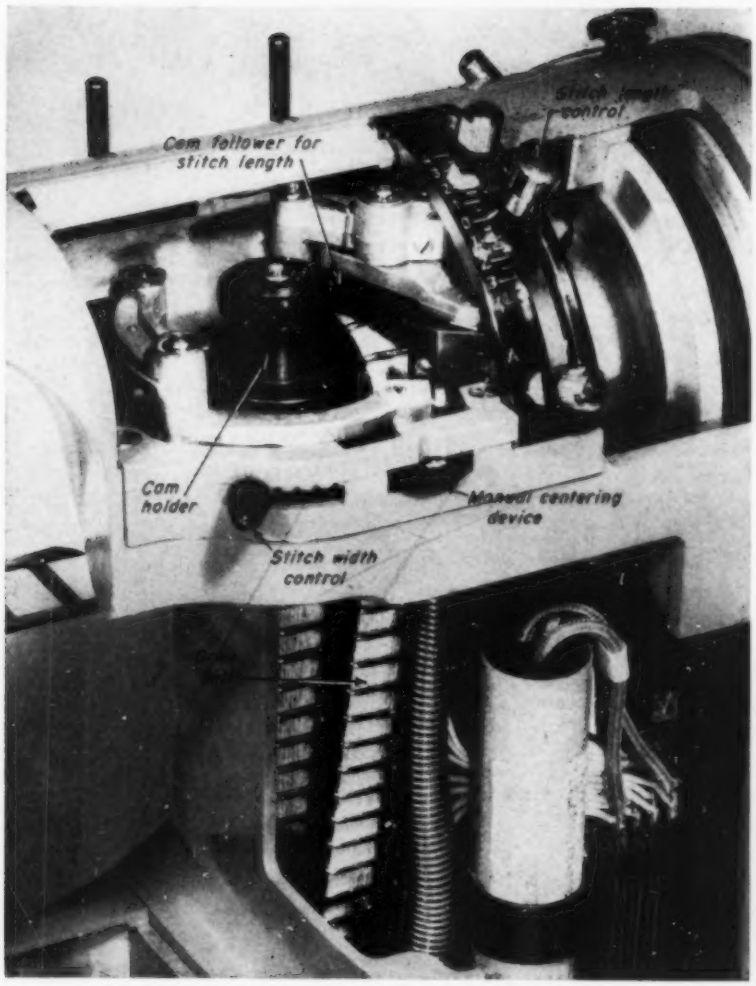

Cam follower linkage to automatically control stitch length
Zig zag stitch cam follower
Manual stitch length control
Stitch width control
Cam holder
Manual centering control

CUTAWAY shows driving mechanism for needle bar. Eccentric provides vertical motion to needle bar through bracket attached to bar. Lever arm from zig-zag cam follower moves C-frame bracket to oscillate needle bar for horizontal motion. For unusual effects the machine may be equipped with a double needle. Cam control of this is the same as when a conventional single needle is used.



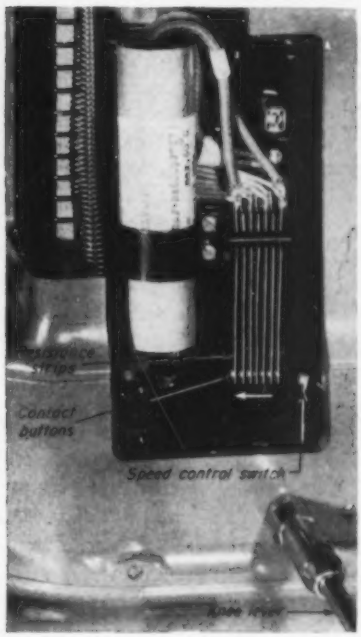
SCHEMATIC of transmission (below) shows how power is transmitted from a single motor to all parts of the machine. Bevel friction wheel replaces conventional bevel gearing because it provides quieter operation. Nylon gears are used throughout the machine, where possible, to help keep machine noise to a minimum. Note that there are two main driving mechanisms: at the top of the machine to supply the horizontal and vertical movement of the needle bar, and at the bottom of the machine to provide rotary motion of the shuttle and the stitch width adjustment.

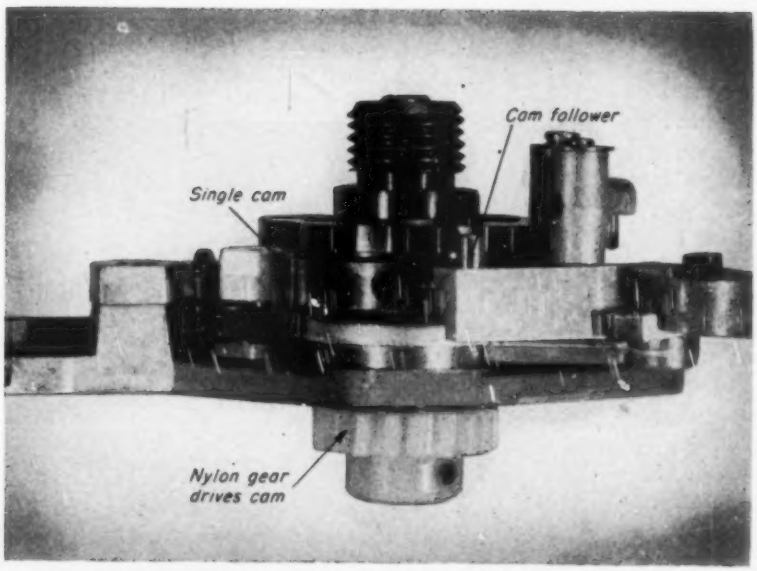




ANOTHER VIEW of Elnagraph shows stitch length cam follower. When stitch width control is set at zero width (as in cut) machine straight stitches like ordinary sewing machine. Note unusual drive belt that transmits power to lower portion of machine. Centering device permits moving needle by hand to check machine before starting.

SPEED control mechanism. Movement of knee lever brings speed control switch against first contact button to put first resistor strip into motor circuit. Since electrical resistance is high, motor speed is low. Additional knee lever movement puts more resistors into the circuit in parallel, decreasing resistance to increase motor speed.





(LEFT) Elnagraph is a complete unit that may be purchased to convert standard Elna sewing machines to automatic zig-zag machines. Nylon gear is used to reduce gear noise.

Bridge-Type Design Toughens New Instrument

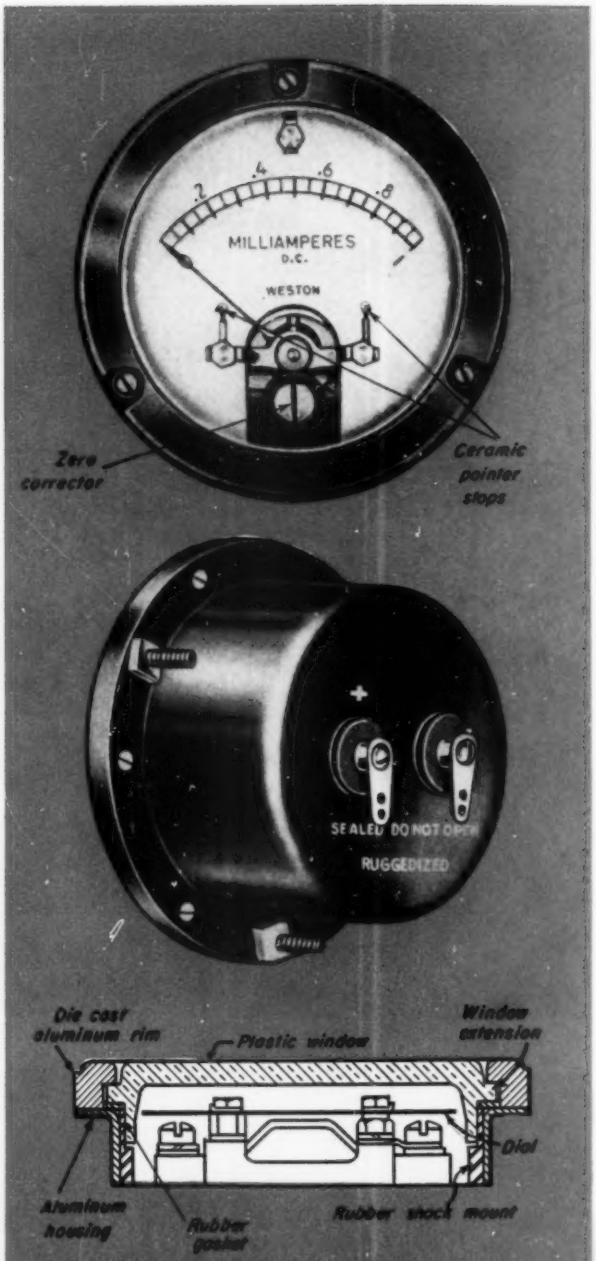
Basic concept in the design of a new line of ruggedized instruments developed by the Weston Instrument Company, Newark, N. J. is the strengthening of moving parts by increasing their torque-weight ratio while decreasing their mass. Many parts have characteristic "bridge design" or truss shapes to withstand severe shock, rough handling, climatic extremes and sudden changes in temperature. These instruments are the latest development in the ruggedization program (see *Product Engineering*, December, 1952, page 146).

In the confined gasket system that hermetically seals the unit, the flat non-breakable thermoplastic window typifies the design theory. The truss shape of the rim edge serves a triple purpose: to increase mechanical strength, to increase dielectric strength and to position the gasket seal. In addition, the use of plastic permits adding a zero corrector.

To protect against heavy shock, Weston doubled the thickness of the metal case since strength is proportional to the cube of thickness; they lined the interior of the case with a rubber that also increases dielectric strength of the instrument; and they located a brass anchor plate in the rubber shock mount so that the mount acts as a spring to absorb energy of heavy blows.

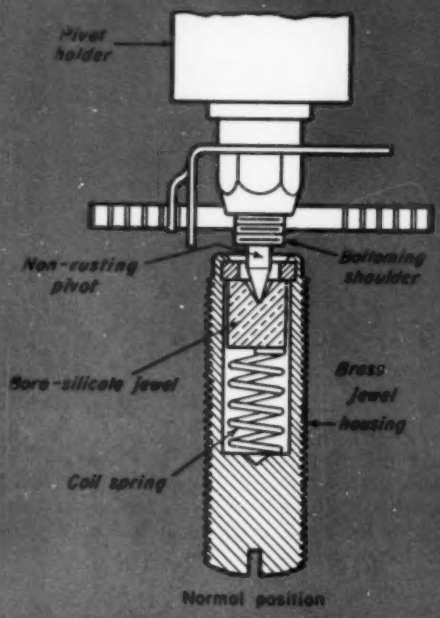
The moving element has been strengthened by a reduction in mass and inertia, and is protected by a box-type reinforced structure that locks the core and lower bridge in position. Boro-silicate glass jewels are spring backed and provided with a shoulder to nullify shock. In the moving coil frame, Weston uses a special aluminum alloy that combines high electrical resistance with good mechanical strength since brass is too heavy.

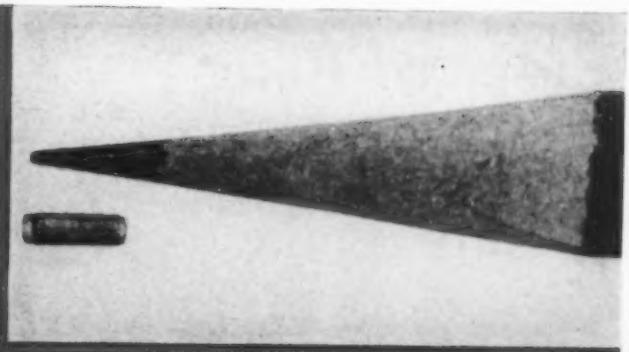
Weston offers two models: (1) Class 52 (described here) for use with back lighting, (2) Class 51 characterized by a full flanged diameter thermoplastic window for use with edge lighting. The Signal Corps has granted qualification approval under specifications MIL M-10304 Sig C. to the Class 52 d-c instruments in ranges from 300 microamperes to eight milliamperes.



UNBREAKABLE plastic window permits full view of instrument dial and use of zero corrector. Tough thermoplastic material is heat resistant, and treated to render it permanently anti-static and scratch-resistant. Ceramic pointer stops also position and lock dial screws. Shock-resistant rear terminals provide high dielectric strength.

CONFINED gasket system of window (below). Edge extension of plastic serves triple purpose: increases mechanical strength, improves dielectric strength by overlapping rubber in housing, and positions gasket to assure hermetic sealing.





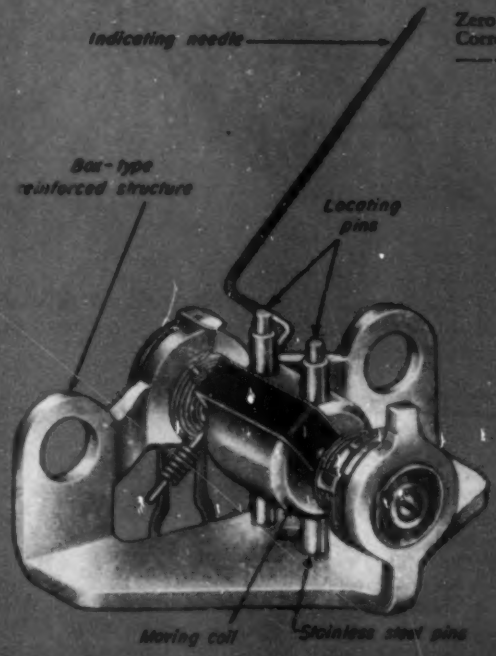
DESPITE SIZE of jewel and pivot holders, note comparison of former to a standard pencil point, both are turned out of brass stock on standard screw machines at rates up to 900 per hr.

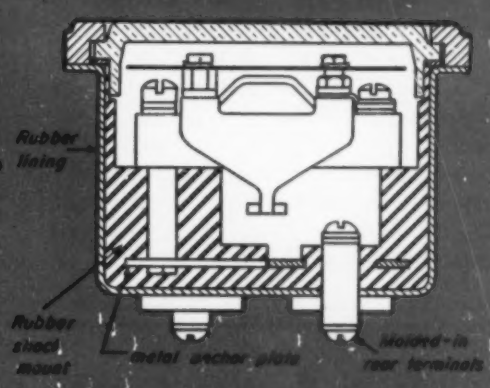
SPRING BACKED boro-silicate jewels nullify effect of shock on jewel mechanism. Shoulder bottom on pivot prevents damage from sudden heavy impact to spring, jewel, or pivot.

Moving coil assembly has a box type structure for added strength and to lock core and lower bridge into position. Stainless steel pins position assembly in proper place. Magnet and moving element combination provides maximum torque-to-weight ratio.

Comparing this instrument to previous ruggedized types there are these major differences:

Item	Previous Type	Weston
Window	Convex Glass	Flat Thermoplastic
Seal	Window soldered to aluminum frame	Confined gasket system
Shock Mount	Bottom of case only	Entire case lined with rubber.
Pole Pieces	Sintered iron	Cold rolled steel
Jewel	Boro-silicate jewels with osmium tipped elgiloy pivots	Boro-silicate jewels, spring-backed, with non-rusting Weston alloy pivots
Zero Corrector	None	Screw driver operated





INTERNAL SHOCK MOUNT consists of metal anchor plate imbedded in specially compounded rubber that has high dielectric strength to prevent carbonizing or flashover. Rubber lining throughout boosts dielectric strength of instrument. Rear terminals, molded into the shock mount, increase mechanical strength.

Tapered Rotor Supplies Built-In Motor Brake

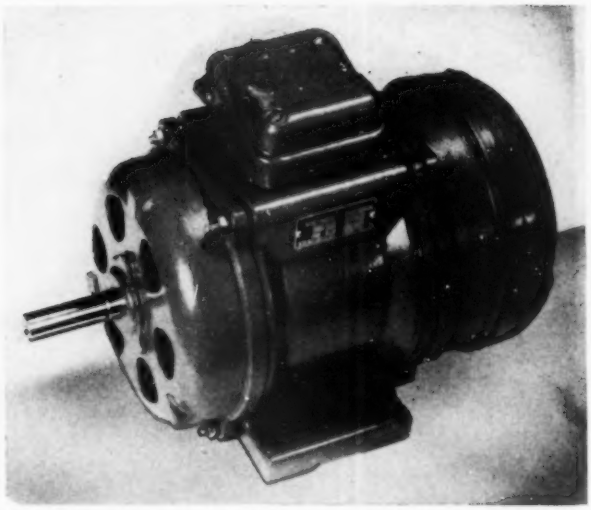
A tapered rotor in the Swiss Brown Boveri "Quick Stop" motor permits combining drive and brake in one unit. When the motor is started, the tapered rotor unbalances the magnetic field so that a horizontal force builds up and moves the rotor horizontally about 3/64 in. to magnetic center. The motor then runs as a conventional squirrel cage induction motor. When the power is shut off the horizontal force disappears. A spring pulls the rotor out of magnetic center and at the same time applies the brake pressure plate to the lining, stopping rotation.

Since the horizontal force is a holding force, no work output is lost when the motor is running. Taper is so slight it has no effect on motor operation.

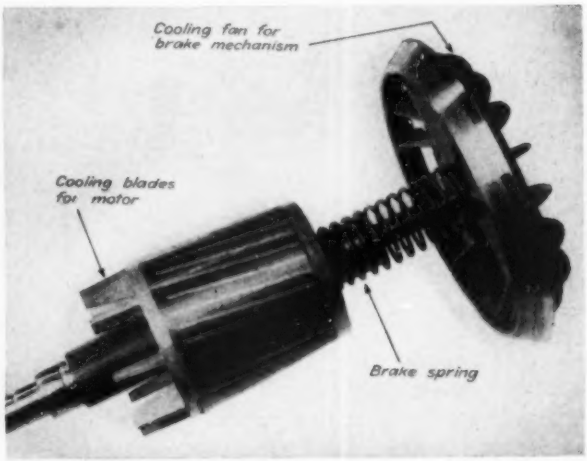
Because the unit has no backlash or tendency to creep, the motor is applicable for drives with frequent starts and stops and when the drive shaft must be held firmly at stand still. The time required to stop the motor after power is off depends on the size of the motor and the inertia of the driven machinery. Since braking torque is approximately equal to average line starting troque, the motor starts and stops with the same speed. It will stop and brake with 150 percent of normal torque.

When using the motor, the type of mounting dictates the spring characteristics. In vertical mounting, a different spring is required when the shaft end is up than when the shaft end is down to offset the effect of gravitational forces.

The motors, 3 phase, 60 cycles, 220/440 volts, are available for forward or reverse operation, and in drip-proof or fully enclosed models. In the United States, the Brown Boveri Corporation, New York, N. Y., distributes this motor.



FULLY ENCLOSED MOTOR with built-in brake uses same frame as conventional motor made by this company. Fully enclosed models are available in ranges from 0.4 to 4 hp; drip-proof models range from 0.5 to 8 hp. Motor was designed and built by Brown Boveri and Co. Limited, Baden, Switzerland for drives that have frequent starts and stops.



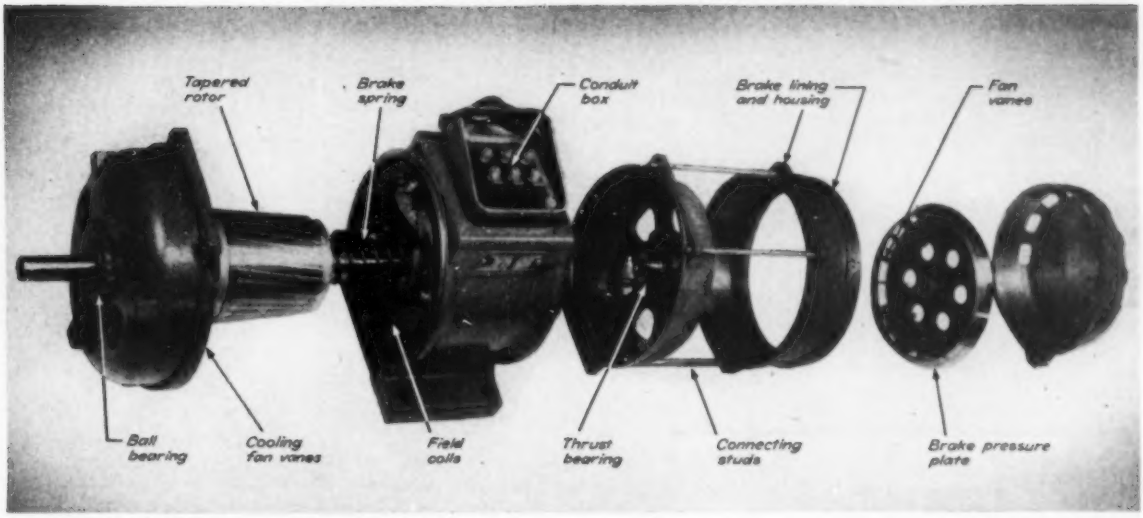
INJECTION MOLDED ROTOR has conical shape, barely noticeable, instead of conventional cylindrical shape. Brake is mounted on end of rotor shaft. Motor cooling fan blades are an integral part of the rotor.

Wear Resistant Coatings to Protect Ferrous Metals

THERE ARE FIVE different kinds of coatings available to protect iron and steel moving parts subject to wear: 1) mechanically applied metal; 2) chemically reactivated; 3) fused or vitreous; 4) electroplated, and 5) miscellaneous films.

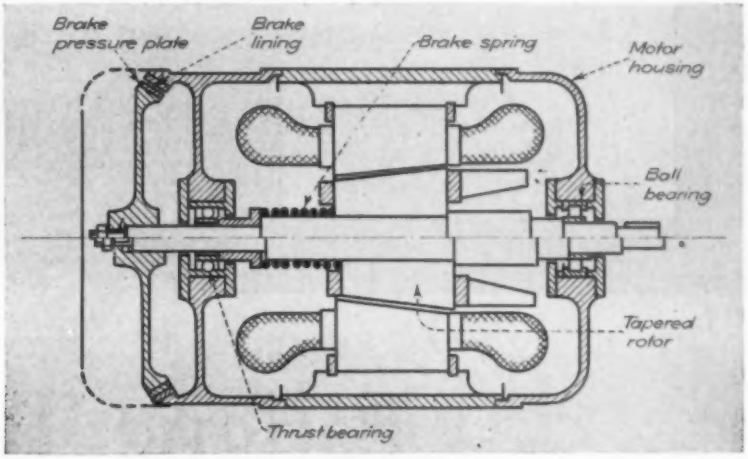
Among the first group, the best known are metal spraying, in which almost every type of metal or metal alloy can be built up to a thickness of an eighth of an inch, hot dipping such as tinning or galvanizing, and welding. Cementation or fusing with powdered metal, not so familiar, builds up protective layers from 0.0004 in. to 0.001 in. thick.

In chemically reactivated films, a chemical reaction occurs between the ferrous part and some reagent. Phosphate treatments form a relatively soft



EXPLODED VIEW OF MOTOR. Ball bearing is designed to permit $\frac{3}{64}$ in. travel of rotor shaft, while thrust bearing absorbs end forces resulting from movement of rotor. For easy maintenance, brake is designed so that entire brake housing is replaced as a unit instead of just the brake lining. Lining will withstand 30,000,000 stops. Motor has two fans: one on rotor shaft cools field coils and armature, one on brake pressure plate cools brake itself. In totally enclosed unit, brake is not enclosed so that brake dust can not work into motor portion of the unit. When motor is running, there is a 0.010 in. air gap between the lining and the pressure plate.

FIELD COILS and housing look like standard motor, but bore has been tapered to match rotor. Interior is finished by turning on a lathe.



IN THIS CROSS-SECTIONAL DRAWING, the upper half shows the motor with the brake released; the lower portion shows components when the brake is applied. When power is turned on, the rotor in the brake applied position unbalances the magnetic field, setting up a horizontal force.

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film of iron phosphate along with zinc or manganese phosphate crystals. Hard thin oxide films can be developed by impinging superheated steam on the iron or steel. Wear resistant properties can be imparted by changing the proportions of elements in the outer layers. Typical examples: surfiding, nitriding, and carburizing.

The use of fused or vitreous films has been expanded by the development of new ceramic coatings. So called porcelain enamels will stand temperatures up to 1,000 F; ceramic coatings take over above that.

Electroplated films, like tin, nickel and chromium are widely used to impart wear resistance to a host of products. The hardest of these probably is chromium at 900 to 1,050 Brinell hardness. Applied as solid or in porous effects chromium coatings are also the most difficult to produce.

Under the classification of miscellaneous coatings fall synthetic mixtures like powdered graphite with resin binder, mica powder, etc.

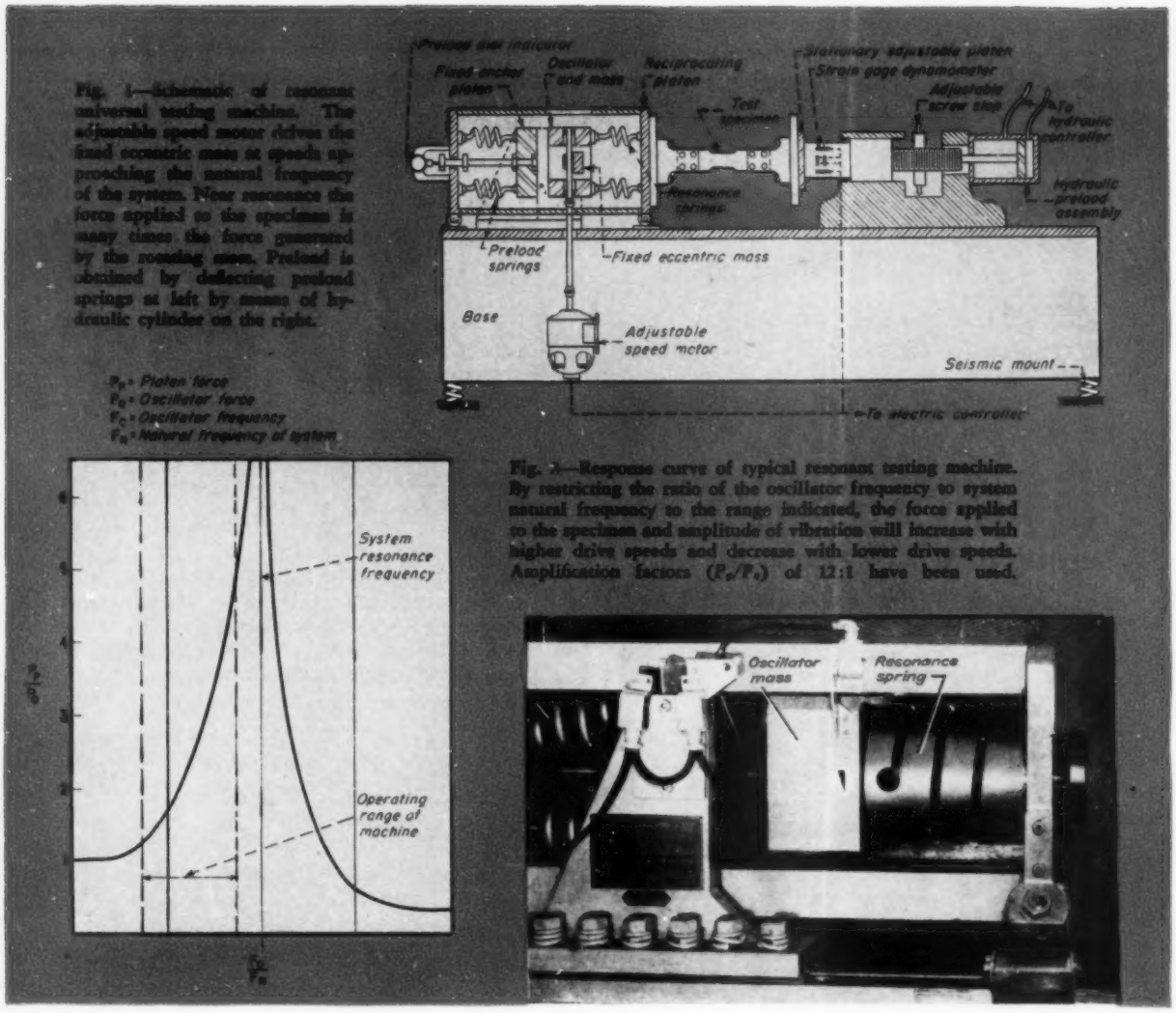

Fig. 1—Schematic of resonant universal testing machine. The adjustable speed motor drives the fixed eccentric mass at speeds approaching the natural frequency of the system. Near resonance the force applied to the specimen is many times the force generated by the rotating mass. Preload is obtained by deflecting preload springs at left by means of hydraulic cylinder on the right.

Fig. 2—Response curve of typical resonant testing machine. By restricting the ratio of the oscillator frequency to system natural frequency to the range indicated, the force applied to the specimen and amplitude of vibration will increase with higher drive speeds and decrease with lower drive speeds. Amplification factors (P_p/P_o) of 12:1 have been used.

Fatigue Testing—Its

This is the second of a series of articles on the practical aspects of deter-

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A GENERAL APPROACH to the problems of fatigue testing, together with details on various types of single-purpose and universal fatigue testing machines were covered in Part I of this article, see *Product Engineering*, February 1953, page 128. Other types of testing machines include a third class of universal machine, semi-special machines, and vibration generators.

The third basic type of universal testing unit is the resonant machine, Fig. 1. This operates on a constant force principle, but with a nonadjustable eccentric mass. Power is supplied by an adjustable speed motor and transmitted to the specimen through a set of resonance springs. The components are selected so that the system is operating near resonance.

The amplitude of vibration of the oscillator is large, Fig. 2. As the speed, F_o, is increased the magnitude of F_o/F_n approaches one and the amplitude builds up. As F_o is reduced the amplitude decreases. This is a typical spring-mass system operating near resonance. The force in the springs, P_p, caused by the large amplitude of vibration, is much greater than the force, P_o, generated by the eccentric mass. In practice these machines operate at

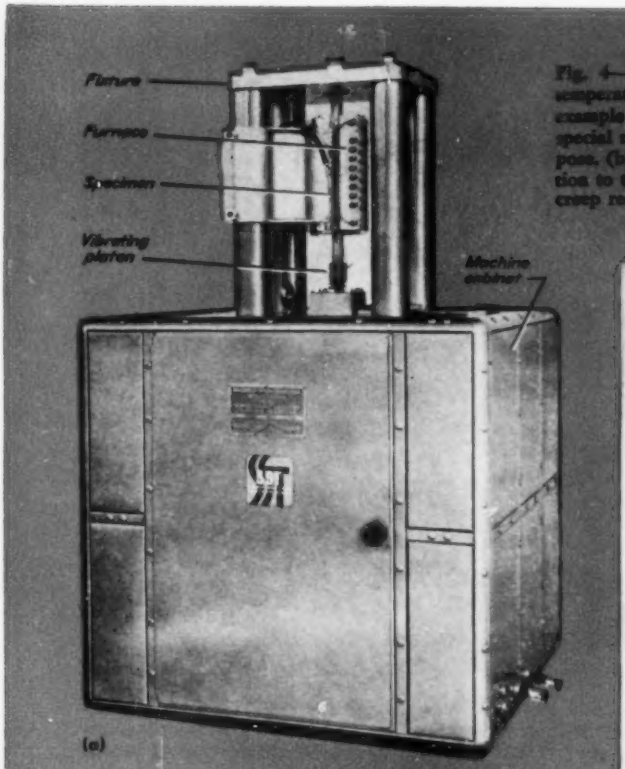


Fig. 3—(Left) Reciprocating or vibrating platen of resonance tester. The specimen is fastened to the right hand end of this platen, and entire unit vibrates as a result of the oscillating forces transmitted through the springs. The oscillator mass and drive motor can be small because of the force multiplication resulting from system characteristics.

Fig. 4—(a) Universal fatigue tester adapted to high cycle, high temperature tension and compression testing. This is a typical example of a standard tester which has been converted to a semi-special machine. Its flexibility is sacrificed to achieve a special purpose. (b) Control cabinet for testing machine shown in (a). In addition to the basic machine equipment, it contains furnace controls, a creep recorder, and a temperature recorder-controller.

Machines and Methods

mining fatigue strengths with various commercial fatigue testing machines.

amplification factors as high as 10 or 12:1. At a figure of 10:1, an eccentric generated force of 2,000 lb develops 20,000 lb in the springs and on the reciprocating platen. This permits the use of smaller motors, eccentrics, and eccentric bearings than is possible in a brute force machine where the eccentric mass generates the full force.

In Fig. 1, the oscillator mass and resonance springs are attached to the working platen. The fixed platen, anchored to the main frame, supports the preload springs. The stationary adjustable platen is preloaded by the hydraulic cylinder and has an adjustable screw stop. The strain gage dynamometer senses the force applied to the specimen and sends a signal to a controller. This signal is compared to an adjustable reference. Any error changes the speed of the electronically controlled adjustable speed drive motor until the signal and reference value cancel. This maintains a constant force cycle on the specimen. In this system, instead of compensating for the inertia forces, they are actually measured as part of the total force.

While this type machine appears to be efficient and simple it has certain complicating characteristics. The vibrating components make up a two-degree-of-freedom system which means that the specimen is part of the spring system and its characteristics affect the

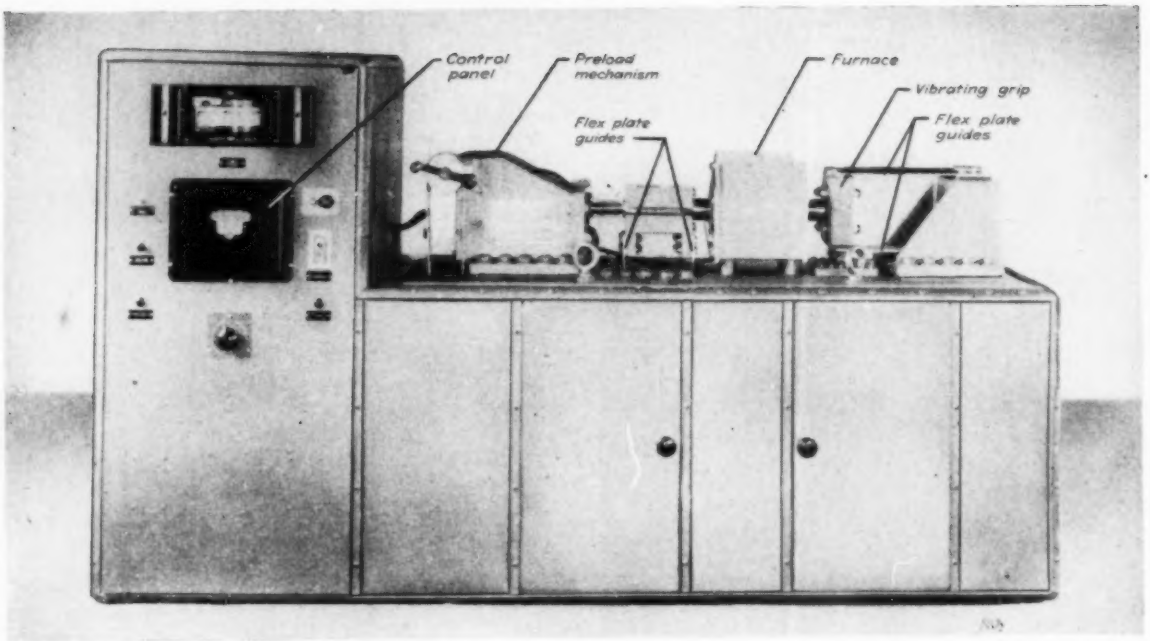


Fig. 5—High temperature tester designed to simulate operating conditions of turbine blades. Left hand grip is mounted on vertical flexplates and transmits a static tensile load to the specimen. Right hand grip is actuated by a vertical vibrator and dynamically loads the specimen in bending. Horizontal flexplates guide this grip. Preload is applied by rotating chain-connected handle.

operating speed of the machine. Any nonlinearity in the specimen will tend to cause nonlinearity in the machine force cycle. Test specimens such as linkages and multiple pin joints can cause nonlinear loads and hammering because their spring constants vary with the load. This has the effect of rapidly shifting the operating point back and forth along the resonance curve with resultant instability.

These machines, while smaller than the brute force units of equal capacity, are also more complex because of the electronic controls necessary to regulate the force output.

In Fig. 3 is shown a close-up of the reciprocating platen of a resonance machine. Since the resonance springs loading cycle is so severe, they are machined out of solid cylindrical forgings and then heat-treated.

Semi-Special Machines

The third class of machines are often special adaptations of universal machines, with some of their flexibility sacrificed to achieve special results. Others in this class are units designed to handle one type of test which warrants a special machine because of its long term requirements.

Several types of fatigue testing machines have been adapted for high temperature testing. A universal machine can be converted for high temperature work by the addition of a specimen furnace and more extensive electronic control equipment, Fig. 4. This particular machine is designed for tension and compression tests at high cyclic speeds and high temperatures. The stroke is limited because of the inertia forces at high speeds.

The electric furnace, surrounding the specimen, has tapped windings that can be shunted to balance the temperature along the gage length of the test piece. The control cabinet is separate and contains a temperature recorder-controller and a creep recorder in addition to the standard universal machine equipment. At high temperatures, creep life is often more important than fatigue life. The creep instrument is a standard temperature recorder integrated with the automatic preload control system to indicate and record the creep of the specimen against time.

Another type of commercially available high temperature test machine is shown in Fig. 5. This unit was designed to apply a fatigue bending load and a tension load to turbine blade specimens. The test blade is mounted between grips in a high temperature furnace. One set of grips is forced to vibrate and applies a bending moment to the specimen. The other grip is spring loaded to apply a static tensile force which simulates the centrifugal force encountered in actual service. Both the tensile and bending loads are adjustable and can be combined in any ratio. The controls are on the left hand end of the machine.

The rail bending fatigue tester, Fig. 6, is a special purpose machine used to repeatedly flex a rail section and simulate track service conditions. The test section is mounted on a reciprocating carriage in such a manner that the single point of rail support moves back and forth under the center of force as applied by the rolling load. This subjects the specimen to an alternating bending moment at the point of support. The magnitude of this moment is determined by the load spring deflection.

A special adaptation of a resonant type machine, Fig. 7, vibrates reed type specimens at or near their natural frequency, applying bending stresses at a high cyclic rate. In this machine, jets of air impinge on each side of the specimen. By tuning the length of the air columns, a resonant condition is reached. Suitable electronic controls adjust the air and tubes to maintain a preset amplitude of vibration.

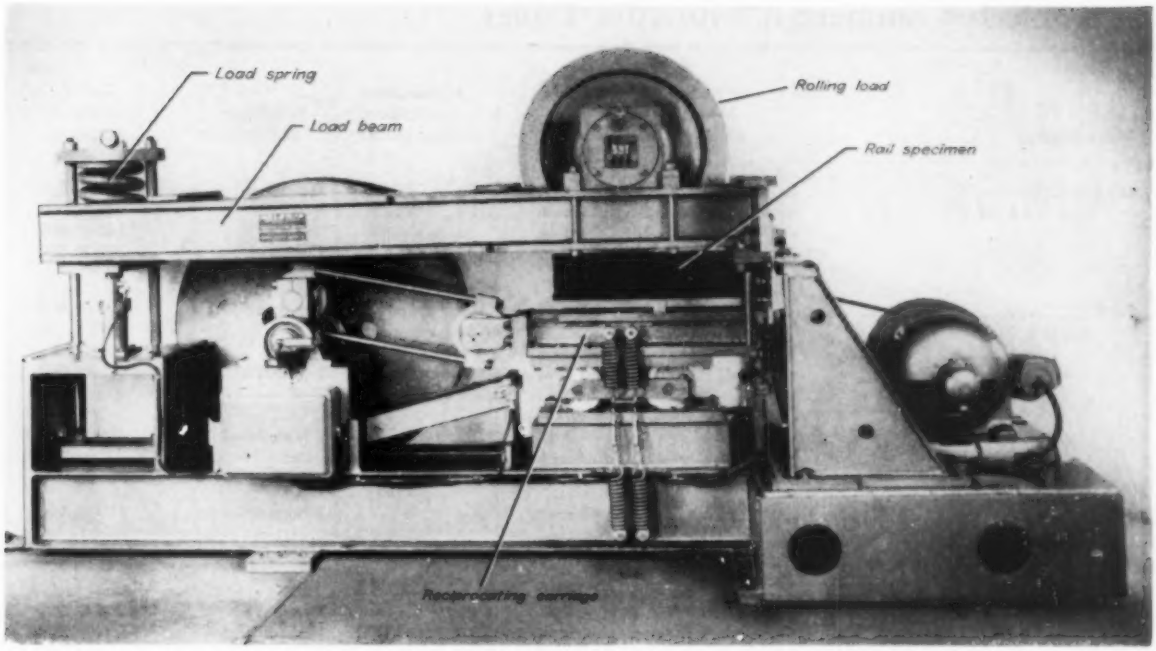


Fig. 6—Special fatigue testing machine designed to subject rail specimens to approximations of track service conditions. Load is applied by deflecting the load spring a predetermined amount. A crank actuated carriage moves the specimen back and forth under the rolling load. Since the rail is only supported at one end and a single other point, it has to resist alternate bending moments.

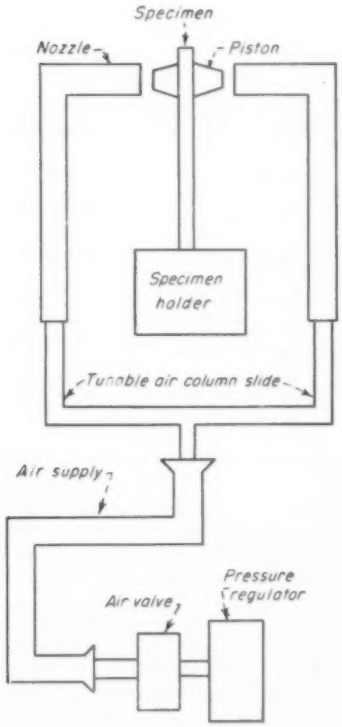


Fig. 7—Reed type resonant tester. Air columns are tuned so that specimen vibrates at its natural frequency. This machine can only be used for limited sizes of reed shaped test pieces and will only apply a dynamic bending load.

Vibration Generators

Vibration generators or oscillators are used to excite a structure to resonance or, when combined with a platform, to subject a structure to a controlled acceleration. Their force generators are similar to those found on fatigue machines, but instead of exerting a controlled force on the specimen and so a controlled stress, these units move the specimen freely in space with a controlled frequency and amplitude. The result is a shaking action or controlled acceleration that tests the strength of the various members and also brings out resonant points. When resonance is reached, the resultant high amplitude usually destroys the part.

If the test is to determine the resonant peaks of internal parts, little generated power is necessary since sensitive instruments can detect these points. However, if the same structure is to be tested for the results of these resonances under forced vibration, large capacities are needed.

In this case the structural members absorb large amounts of energy at resonance. If sufficient power is not available, the maximum amplitudes will not be reached and true test results will not be obtained. Actually under these conditions the specimen may drive the oscillator and reduce the stresses to low values. Tests have been run on identical instruments and assemblies using large and small oscillators to verify this affect. On low powered equipment the test pieces withstood the applied acceleration, but when subjected to identical tests on high powered oscillators they disintegrated. This shows that under resonant conditions inadequate power cannot maintain set conditions and the specimen is not actually subjected to the desired accelerations.

Another factor in the selection of a vibration generator is the weight of the specimen. Most of these machines are either rated in force vector pounds available or in the number of pounds capacity. These terms can be misleading. The force required is not only the specimen weight times the acceleration in g's, but also has to include the weight of the holding fixture and possibly instrumentation. If a test is to be run at 20 g's, every pound of fixture and specimen actually corresponds to 20 pounds. As an example, assume a 20 lb instrument is to be tested at 15 g's. If the holding fixture weighs 5 lb, the total weight is 25 pounds. At an acceleration of 15 g's a total force of 15 times 25 or 375 lb is required. A 500 lb machine would probably be selected.

In addition, a machine rated 100 lb

Table I—Commercial Vibration Tables

Manufacturer	Model Number	Table Size, inches	Maximum Specimen Weight, pounds	Plane of Vibration	Speed Range, rpm
Waugh Equipment Co. New York, N. Y.	VMJ-2-HB	18 x 18½	150	Horizontal	600–3,600
	VMJ-4-VB	18 x 24	100	Vertical	600–3,600
	VMJ-3-CC	24 x 24	35	Circular	300–3,600
	VMJ-3-CD	24 x 24	100	Circular	300–3,600
L. A. B. Corp. Summit, N. J.	VU-DM-100	24 x 30	100 vertical 50 horizontal	3 planes	600–3,600
	VU-DM-500	36 x 48	500 vertical 250 horizontal	3 planes	600–3,600
	R V 3	24 x 40¾	100	2 horizontal planes	600–3,600
Henry & Wright (Western Electric Patents) Hartford, Conn.		48 x 48	500	2 horizontal and 2 vertical planes, circular	600–3,600
All American Tool & Manufacturing Co. Chicago, Ill.	10 VA	8 x 8	10	Vertical	600–3,600
	10 HA	7 x 12	10	Horizontal	600–3,600
	25 H	12 x 15	25	Horizontal	600–3,600
	25 HA	12 x 15	25	Horizontal	600–3,600
	100 H	12 x 18	100	Horizontal	600–3,600
	100 HA	12 x 18	100	Horizontal	600–3,600
	100 V	12 x 18	100	Vertical	600–3,600
	100 VA	12 x 18	100	Vertical	600–3,600
M. B. Corp. New Haven, Conn.		8.5 dia	200 lb force output	Vertical	180–30,000
Sonntag Scientific Corp. Greenwich, Conn.	SV-25	11 x 14	25	Horizontal	1,800–18,000
	SV-100	24 x 36	100	Horizontal	1,800–12,000
	SV-200	30 x 42	200	Horizontal	600–6,000
	SV-500	36 x 48	500	Horizontal	600–3,600
	SV-1000	48 x 72	1000	Horizontal	600–3,600
Government Specifications				Circular 45 deg Vertical or horizontal	500–3,000 500–3,000

at 10 g's cannot be assumed to give 100 g's with a 10 lb load. Most machines are rated at maximum g's at full stroke, so that a reduction in specimen weight will not increase the available acceleration. There are a few machines however, that are rated at a lower acceleration for large specimens and a higher acceleration for light specimens. Each machine's specifications should be carefully considered.

Commercial oscillators, Table I, are divided into three groups: the crank or brute force type, the free eccentric or reaction type, and the electric type.

The crank type is similar to the constant amplitude fatigue machine, using an adjustable crank and connecting rod to move a platen or table back and forth. It has no fixed platen, and the oscillating table is large, with a grid of tapped holes for fastening the specimen. Any amplitude and frequency can be obtained since the stroke and speed are both adjustable. The drive motor can be made to cycle automatically between set limits to meet vibration testing specifications.

These machines are made to test specimens in several planes. Some only vibrate in one plane, others in two planes, and one type vibrates in three planes with individual stroke adjustments in each plane. Some models also have provision for generating rotary motion, and one type moves in a plane 45 deg to the horizontal.

Speeds range from 10 to 60 cps, and machines are available that will handle specimens up to 500 lb at 10 g's. Maximum stroke is 1 in. for light specimens with an acceleration limit of 15 g's. The base absorbs all of the bearing reaction forces and must be mounted on a substantial foundation.

The free eccentric type oscillator uses unbalanced weights to generate the vibration force. The weights are

Double Amplitude, inches	Automatic Cycling	Maximum Acceleration, g's	Mounting	Remarks
0–0.0625	Yes	12	Concrete base	Cam type
0–0.0625	Yes	12	Concrete base	Cam type
0–0.062	Extra		Concrete base	Cam type
0–0.062	Extra		Concrete base	Cam type
0–0.500 Adjustable while running	Yes	10	10 ton base required	Cam type, load center of gravity 3 in. above table
0–0.25 Adjustable while running	Yes	10	50 ton base required	Cam type
0–0.125	Extra	10	Seismic (no foundation needed)	Reaction type, above resonance operation
0–0.258	Yes	10		Cam type
0–0.200	Yes	37	Base required	Cam type
0–0.200	Yes	37	Base required	Cam type
0–0.125	No	23	Base required	Cam type
0–0.125	Yes	23	Base required	Cam type
0–0.125	No	23	Base required	Cam type
0–0.125	Yes	23	Base required	Cam type
0–0.125	No	23	Base required	Cam type
0–0.125	Yes	23	Base required	Cam type
0–1.	No	See Capacity	Base required	Electric magnetic
0–0.020	Yes	20	Seismic (no foundation required)	Reaction type, above resonance operation. Max. load c.g. above table—6 in.
0–0.060	Yes	20	Seismic (no foundation required)	Reaction type, above resonance operation. Max. load c.g. above table—9 in.
0–0.060	Yes	15	Seismic (no foundation required)	Reaction type, above resonance operation. Max. load c.g. above table—12 in.
0–0.108	Yes	20	Seismic (no foundation required)	Reaction type, above resonance operation. Max. load c.g. above table—15 in.
0–0.128	Yes	24	Seismic (no foundation required)	Reaction type, above resonance operation. Max. load c.g. above table—24 in.
0.018 0.002–0.020				

usually mounted on two shafts that rotate in opposite directions, and are phased so that they cancel each other in one plane and are additive in the other plane. This produces a sinusoidal force along one axis.

A small oscillator of this type, Fig. 8, generates a maximum force of 1,600 pounds. It has three eccentric masses per shaft, with the two shafts geared together. The two end eccentric masses on each shaft are in phase with each other, while the center mass can be rotated with respect to the end weights. The center weight is equal to the combined weight of the two end weights, so that when they are 180 deg out-of-phase the eccentric forces cancel. When they are in-phase the forces are additive and maximum force output is obtained. Since the two shafts are geared together, changing the phase setting of one shaft automatically changes the other. This system limits the force to one axis and permits it to be changed while running.

These units are used to test for resonant conditions in structures such as airplanes or ships, and are bolted directly to the equipment under test. Speeds range from 5 to 120 cpm. Lead eccentric weights can be added to increase their force capacity at low speeds. By replacing the timing gears with a chain drive, rotary instead of linear forces can be obtained.

When specimens rather than structures are to be tested, these oscillators are built into tables on which the test pieces can be mounted. The table is supported on flexplates, and the spring and mass constants are selected so that the machine operates above resonance. Above resonance, the amplitude of vibration is equal to the eccentric mass times its unbalance divided by the mass of the vibrating system, and is not affected by frequency. This gives

Fig. 8—A 1,600 lb package type oscillator. Unit is bolted directly to the structure to be tested and only develops a vibrating force along one axis. The eccentrics are adjustable so that this force can be varied over a specified range during the test.

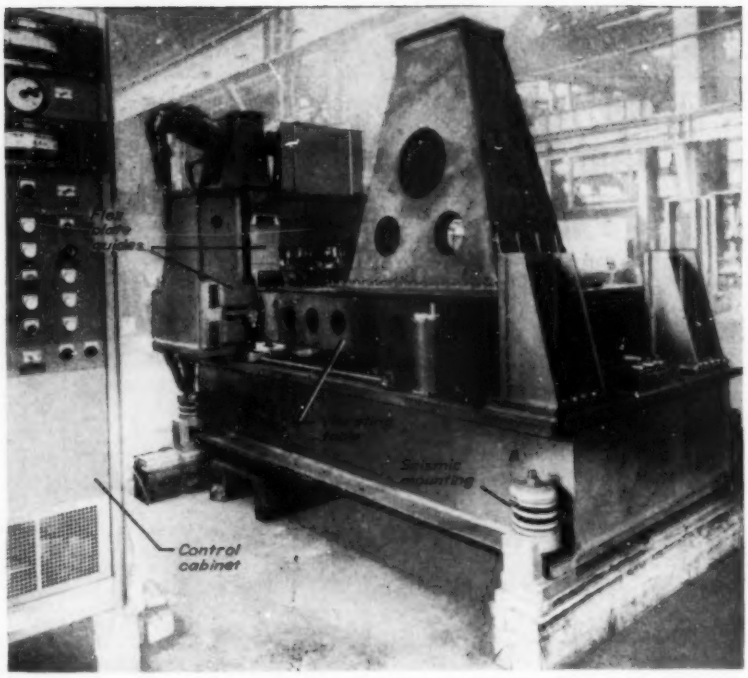
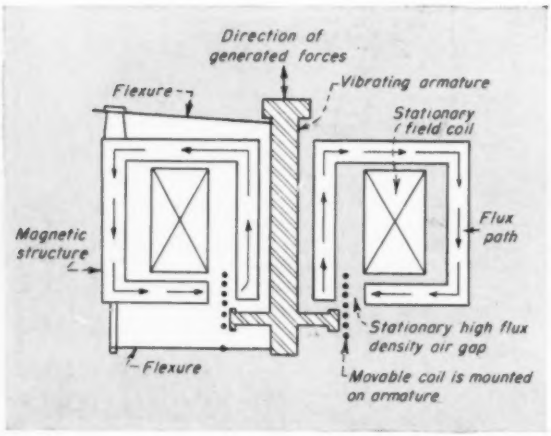
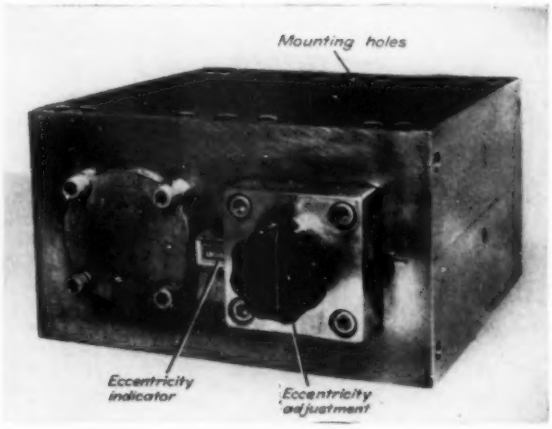


Fig. 9—Large vibration generator. The table is mounted on flexplates and vibrated by rotating eccentric masses. This particular machine has two eccentrics driven by a 30 hp motor. The maximum specimen weight is 1,000 lb, with a maximum height of 24 in. to the center of gravity. Frequency ranges from 10 to 60 cps.

Fig. 10—Schematic arrangement of electromagnetic vibration exciter. Unit is similar to solenoid in which the armature is guided by flexplates. The rate and amplitude of vibration depend on the frequency and magnitude of the exciting voltage. The specimen to be tested is mounted directly on the vibrating armature.





a constant amplitude test over a wide range of frequencies with a given eccentric setting.

Oscillator tables range in size from small 100 lb capacity units to machines that are capable of vibrating 1,000 lb specimens with an acceleration of 24 g's at 60 cps. The latter machine is shown in Fig. 9. The oscillator generates 10,000 lb of force at 60 cps. This will drive a 1,000 lb specimen with a center of gravity 2 ft above the table up to 24 g's on a continuous basis. It is not affected by specimen resonances because 75 percent of the machine load is in the vibrating members.

Some tables have eccentrics that are adjustable during a test. These can be controlled to give constant amplitude over the operating speed range; or by adjusting the eccentricity, can maintain a constant acceleration. This type are called reaction tables since their oscillators cause no external reaction. A vibration absorbing foundation is not required.

Electric oscillators, Fig. 10, are similar to solenoids in which the core is suspended on flexplates in a magnetic field. The strength and polarity of the field vary with the sine wave exciting voltage, and the core moves with a frequency and amplitude dependent on this voltage.

To vary the frequency of vibration, a variable frequency exciting voltage is necessary. This is obtained from a rotary power pack, consisting of alternators driven by variable speed d-c motors. The exciting frequency varies directly with the d-c drive speed.

These units have force capacities up to 2,500 lb and can vibrate at frequencies up to 500 cps. Table travel is limited to $\frac{1}{4}$ in. The acceleration which can be obtained depends on the travel and on load weight. Auxiliary coils on the armature give a velocity signal, and suitable integrating circuits give displacement readings. Test assemblies and structures are excited by directly mounting them on the armature.

Each type of commercial fatigue testing machines has its own operating characteristics. No machine will do everything and every individual unit will give its best results over a limited design range. A machine should be selected so that its operating principles fit in with a planned program.

Factors of Safety In Tolerance Specifications

Many gaps still exist in the practice of the principles for interchangeable manufacturing. One of these is an accurate evaluation for factors of safety necessary in the specification of tolerances as based on statistical quality control.

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TO CORRECTLY EVALUATE tolerance limits, the engineer has to consider two important factors. First, the requirements of a design should be determined so that cumulative variations in part size do not result in defective assemblies. In this manner, permissible maximum tolerances are established. The second factor concerns the capabilities of fabrication processes for achieving desired tolerances. Consecutive pieces vary slightly in a given dimension and, in a run of hundreds of pieces, the range of differences in size increases appreciably. Thus, it is the process capability of production tools that determines the permissible minimum tolerance.

But the very fact that a minimum variation in size can be held does not necessarily mean that the process will or should be expected to do so under all conditions. Changes occur in the machine tools and in their operation—bushings wear, cutting edges become dull, operator skills vary or a process setting may not always be at the exact center of the specification. And once fabrication is complete, there should be provision for inspection errors that might occur in estimating the quality of work by sampling. A tolerance should include an allowance for all these conditions, in addition to compensating for dimensional variations inherent to tools or processes.

The tolerance specified should, therefore, be set below the upper limit determined by the requirement of the design, here called upper tolerance limit; and above the lower limit as dictated by the capability of the process, here called lower tolerance limit. Between the process capability and the specified tolerance is a spread in which manufacturing and inspection operations must be controlled. To do this economically, the tolerance specified should be as close as possible to the upper tolerance limit, so as to give the widest possible manufacturing spread.

It is in this gap between the upper tolerance limit and the specified tolerance that designers retain a part of the permissible tolerance as a factor of safety. The use of these factors in tolerances is somewhat different from their use in strength of materials. Precise working rules based upon conditions such as fatigue, impact loading and deterioration in service have been designated for safety factors in the strength of a part. Though designers generally agree that safety factors are important in specifying tolerances, there is no accepted procedure for their precise application. But, with the emergence of statistical techniques for exercising dimensional control, it is possible to express this tolerance requirement clearly and with precision.

Classification of Quality Characteristics

A basic consideration when dealing with the factor of safety in tolerance is the classification of quality characteristics. Quality cannot be controlled unless the characteristics of dimensions are clearly understood by engineering, production and inspection. Once these are defined, the general classification of characteristics breaks down into three groups: critical, major and minor.

The critical group includes those which by themselves could cause the failure of an assembly or danger to those using it. An example would be the welding of a combustion engine valve head to its stem. The occurrence of just one defective weld in a large sample is sufficient grounds for the rejection of an entire lot, because a broken valve could cause complete engine failure. Processing controls to prevent the manufacture of valves with unsound welds are about the only answer to this type of quality characteristic.

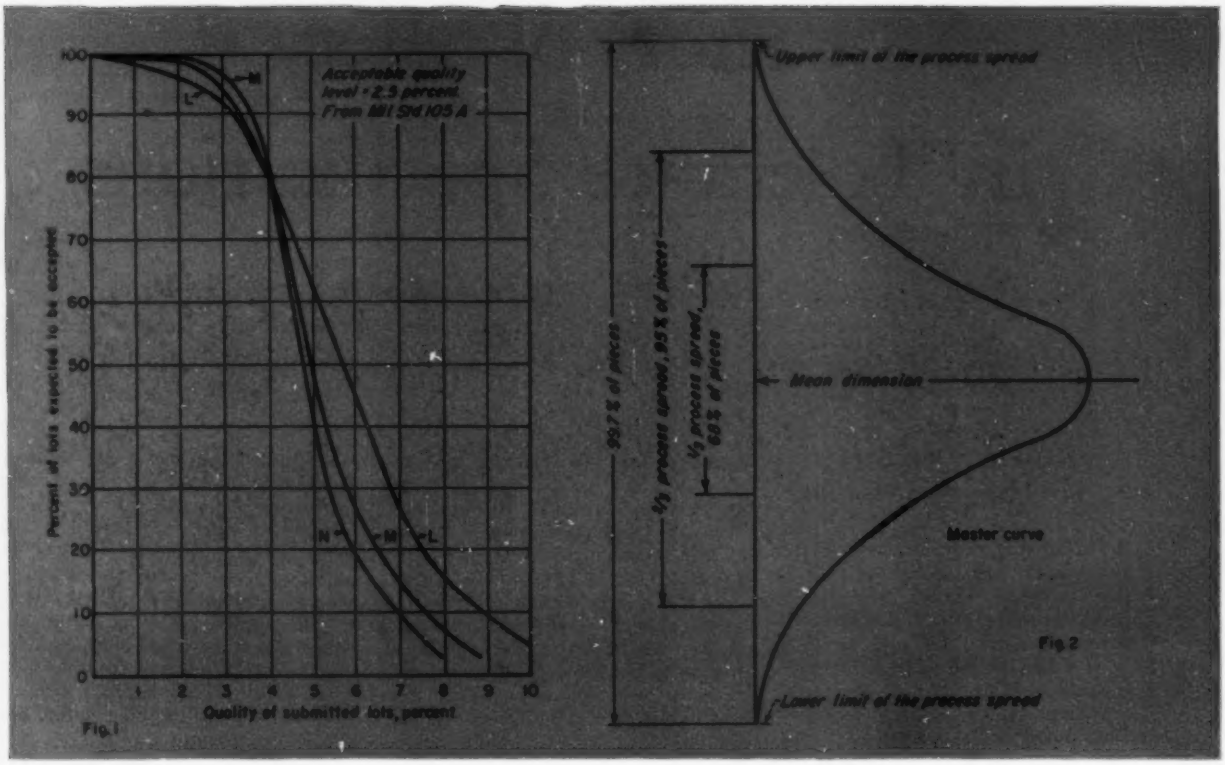
Major characteristics are the functional dimensions of a part, other than critical. The risk of a defective assembly is small when an occasional piece slightly exceeds the specification tolerances. Because the assembly can tolerate these slightly out-of-tolerance pieces, it is possible to rely upon inspection sampling for quality assurance. In such instances, it is advisable to include in the tolerance a factor of safety that is expressed in terms of an acceptable quality level.

Minor quality characteristics refer to all other dimensions and relate to those defects that do not materially reduce the value or utility of a part or assembly. In many such instances, factor of safety considerations on these quality characteristics can be disregarded in favor of expediency in inspection.

The Inspection Operation

There being a possibility that the inspection department will pass work slightly exceeding the specified tolerance, a factor of safety is used to protect the design against this eventuality. It is therefore necessary to understand the inspection problem before the proper safety factor can be specified.

The inspection function is limited by its inability to give quality assurance except at a permissible percentage of out-of-tolerance pieces and at a calculated risk of being in error. The permissible value of this percentage,



as used by the designer, is not generally specified.

Modern statistical inspection methods provide inspection plans where the factor of safety is expressed as an acceptable quality level (A.Q.L.) and a calculated risk of accepting bad material or rejecting good. Every plan can be expressed in terms of an operating characteristic curve, three of which are illustrated in Fig. 1. Curve *M* shows the risk of accepting or rejecting lots when a 225-piece sample is examined. A rejection is made when twelve out-of-tolerance pieces are found, and an acceptance made if eleven or less defective pieces occur. Lots that are two percent defective will pass this plan 99 percent of the time, while lots that are five percent defective will be accepted only 55 percent of the time. Curve *N* illustrates the risk when parts are accepted on 14 and rejected on 15 in a sample of 300 pieces; curve *L* is the risk of a plan for a sample of 150 pieces with acceptance on eight and rejection on nine.

The three curves just described are known as 2.5 percent A.Q.L. curves. If a given lot is better than 2.5 percent defective, the plan will reject progressively, fewer shipments.

It should also be noted that these plans permit the acceptance of higher percentages.

Table I—Limits of Process Average

UPPER LIMITS									
Acceptable Quality Level, percent									
0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10.0
0.555	0.772	1.061	1.492	2.04	2.78	4.15	6.09	9.16	13.30
0.518	0.724	1.000	1.415	1.95	2.66	4.00	5.90	8.92	13.00
0.485	0.683	0.948	1.348	1.87	2.56	3.87	5.73	8.71	12.74
0.461	0.651	0.907	1.296	1.80	2.48	3.77	5.60	8.54	12.54
0.440	0.625	0.874	1.255	1.75	2.42	3.69	5.50	8.41	12.37
0.424	0.604	0.847	1.220	1.71	2.37	3.59	5.41	8.30	12.24
0.405	0.579	0.817	1.181	1.66	2.31	3.54	5.32	8.18	12.08
0.383	0.550	0.779	1.134	1.50	2.23	3.45	5.20	8.03	11.90
0.358	0.518	0.739	1.083	1.54	2.16	3.35	5.07	7.87	11.70
0.328	0.480	0.691	1.021	1.46	2.06	3.23	4.92	7.67	11.46
0.300	0.444	0.645	0.962	1.39	1.97	3.11	4.77	7.49	11.22
0.280	0.418	0.612	0.920	1.34	1.91	3.03	4.67	7.36	11.06
0.266	0.400	0.590	0.892	1.30	1.87	2.97	4.60	7.27	10.95
0.254	0.384	0.570	0.866	1.27	1.83	2.92	4.54	7.18	10.85
0.243	0.371	0.552	0.844	1.24	1.80	2.88	4.48	7.11	10.76

Acceptable Quality Level and Worst Pieces

The concept of a factor of safety in tolerance expressed as an acceptable quality level is not complete without an understanding of the relationship between the A.Q.L. and worst pieces to be expected in the lot.

Size variations from industrial processes generally conform to normal distributions. The plot in Fig. 2 shows the frequency with which different sizes larger or smaller than the average occur. This pattern is clearly evident in Fig. 2 (A), which is the frequency distribution for dimensional variation

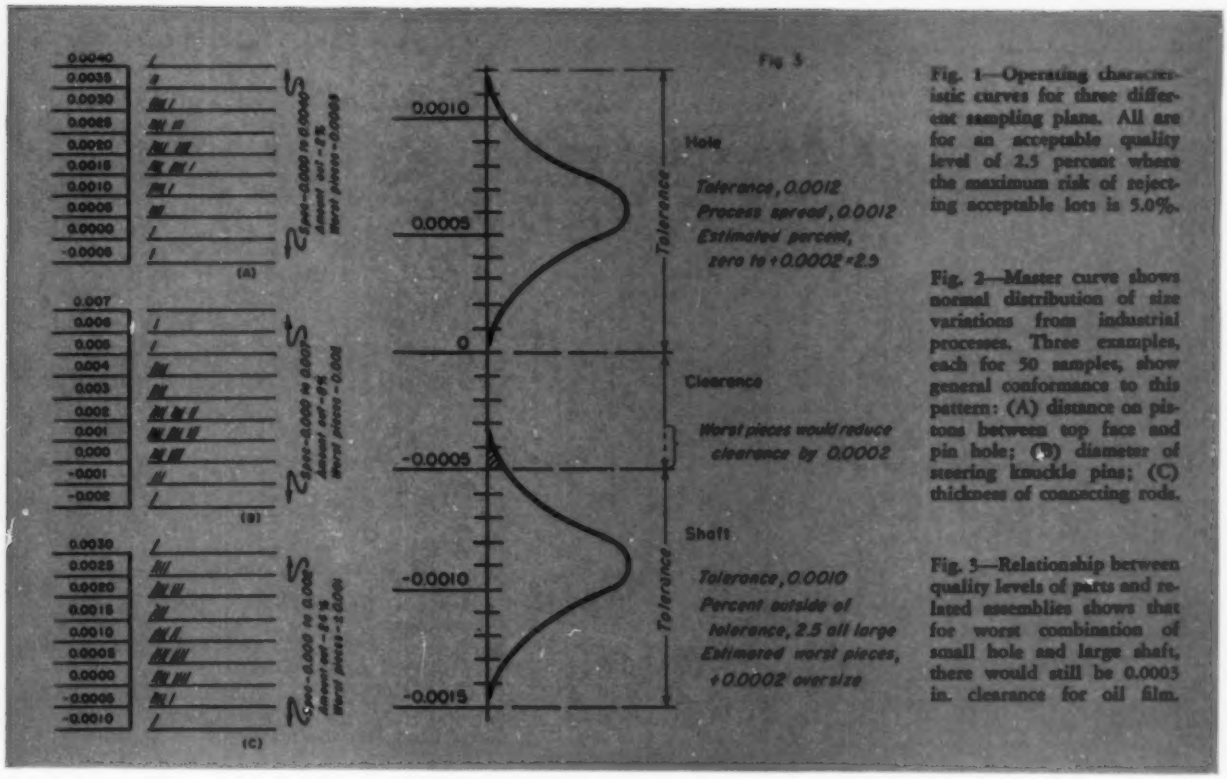


Fig. 1—Operating characteristic curves for three different sampling plans. All are for an acceptable quality level of 2.5 percent where the maximum risk of rejecting acceptable lots is 5.0%.

Fig. 2—Master curve shows normal distribution of size variations from industrial processes. Three examples, each for 50 samples, show general conformance to this pattern: (A) distance on pistons between top face and pin hole; (B) diameter of steering knuckle pins; (C) thickness of connecting rods.

Fig. 3—Relationship between quality levels of parts and related assemblies shows that for worst combination of small hole and large shaft, there would still be 0.0003 in. clearance for oil film.

for Acceptable Quality Levels from 0.15 to 10.0

Number of Sample Units Included in Estimated Process Average	LOWER LIMITS									
	Acceptable Quality Level, percent									
	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10.0
750–899	No Reduced Inspection For					0.22	0.85	1.91	3.84	6.70
900–1,099					0.05	0.34	1.00	2.10	4.08	7.00
1,100–1,299					0.13	0.44	1.13	2.27	4.29	7.26
1,300–1,499	Small Samples			0.004	0.20	0.52	1.23	2.40	4.46	7.46
1,500–1,699				0.045	0.25	0.58	1.31	2.50	4.59	7.63
1,700–1,899				0.080	0.29	0.63	1.41	2.59	4.70	7.76
1,900–2,249	And Low A.Q.L.			0.119	0.34	0.69	1.46	2.68	4.82	7.92
2,250–2,749			0.021	0.166	0.40	0.77	1.55	2.80	4.97	8.10
2,750–3,499			0.061	0.217	0.46	0.84	1.65	2.93	5.13	8.30
3,500–4,999		0.020	0.109	0.279	0.54	0.94	1.77	3.08	5.33	8.54
5,000–6,999		0.056	0.155	0.338	0.61	1.03	1.89	3.23	5.51	8.78
7,000–8,999	0.020	0.082	0.188	0.380	0.66	1.09	1.97	3.33	5.64	8.94
9,000–10,999	0.034	0.100	0.210	0.408	0.70	1.13	2.03	3.40	5.73	9.05
11,000–13,499	0.046	0.116	0.230	0.434	0.73	1.17	2.08	3.46	5.82	9.15
13,500–17,499	0.057	0.129	0.248	0.456	0.76	1.20	2.12	3.52	5.89	9.24

observed when measuring a sample of 50 pistons for the distance between the piston pin and the top face. One piece, or two percent, is outside of the tolerance. It will be noted, however, that the relationship between the two percent and the extent of the worst condition is 0.0005 in a tolerance of 0.0040. A sample of 1,000 pistons would show an increasing spread in the worst pieces, but the relationship would still hold.

A similar frequency distribution taken on the diameter of a ground pin for a steering knuckle is shown in Fig. 2 (B). Eight percent of the 50 samples, is outside the specification and the worst condition is 0.002 in a 0.007 tolerance, all on one side of the specification. In a third instance, Fig. 2 (C) shows a frequency distribution for measurements on the thickness of 50 connecting rods. 24 percent of the samples are outside the specification range of 0.002 and the worst pieces are 0.001 high and 0.001 low. Here again is a relationship between the quality level or the percentage of out-of-tolerance work, and the extent of worst prices. (*continued next page*)

Table III—Master Table For Normal and Tightened Inspection (Double Sampling)

Sample Size Code Letter	Sample	Sample Size	Cumulative Sample Size	Acceptance Quality Levels For Tightened Inspection Use Column III In Table II For Code Letter: 0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10.0
				Acceptance Quality Levels For Normal Inspection Use Column II In Table II For Code Letter: 0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10.0
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
D	1st	5	5	↓	↓	↓	↓	↓	↓	↓	*	*	↓	1 3
	2nd	10	15											2 3
E	1st	7	7	↓	↓	↓	↓	↓	↓	*	↑	↓	0 3	1 5
	2nd	14	21										2 3	4 5
F	1st	10	10	↓	↓	↓	↓	↓	*	↑	↓	0 3	1 4	2 6
	2nd	20	30									2 3	3 4	5 6
G	1st	15	15	↓	↓	↓	↓	*	↑	↓	0 3	1 4	1 5	3 7
	2nd	30	45								2 3	3 4	4 5	6 7
H	1st	25	25	↓	↓	↓	*	↑	↓	1 3	1 4	2 5	3 7	5 11
	2nd	50	75							2 3	3 4	4 5	6 7	10 11
I	1st	35	35	↓	↓	*	↑	↓	0 3	1 3	1 5	2 7	3 12	6 15
	2nd	70	105						2 3	2 3	4 5	6 7	11 12	14 15
J	1st	50	50	↓	*	↑	↓	0 3	1 4	1 6	2 7	3 10	5 15	8 21
	2nd	100	150					2 3	3 4	5 6	6 7	9 10	14 15	20 21
K	1st	75	75	*	↑	↓	0 3	1 3	1 6	2 8	4 9	5 12	7 20	12 29
	2nd	150	225				2 3	2 3	5 6	7 8	8 9	11 12	19 20	28 29
L	1st	100	100	↑	↓	0 3	1 4	1 6	2 6	3 8	5 12	7 17	10 31	14 49
	2nd	200	300			2 3	3 4	5 6	5 6	7 8	11 12	16 17	30 31	48 49
M	1st	150	150	↓	0 3	1 3	2 5	2 7	3 8	5 14	7 19	11 29	15 47	21 65
	2nd	300	450		2 3	2 3	4 5	6 7	7 8	13 14	18 19	28 29	46 47	64 65
N	1st	200	200	0 3	1 3	1 6	2 7	3 8	4 10	6 17	9 25	12 36	18 67	27 89
	2nd	400	600	2 3	2 3	5 6	6 7	7 8	9 10	16 17	24 25	35 36	66 67	88 89
O	1st	300	300	1 3	1 6	2 7	3 9	4 11	6 17	8 26	12 36	18 55	26 88	38 123
	2nd	600	900	2 3	5 6	6 7	8 9	10 11	16 17	25 26	35 36	54 55	87 88	122 123

↓ Use first sampling below arrow ↑ Use first sampling plan above arrow *Use corresponding single sampling plan

Relationship Between Quality Levels of Parts and Assemblies of Such Parts

The quality level of assemblies is better than the quality level of the parts from which they are made. Suppose for example, there are two parts, a shaft and a hole, and that they are to be assembled in large numbers. Suppose further, that the hole sizes are evenly distributed about the center of the tolerances and that the full spread of the tolerance is being used. The resulting condition will be somewhat similar to Fig. 3, wherein the percentage of pieces at various segments of the specification can be estimated. For example, if the specification range or process spread for the hole is 0.0012, 2.5 percent might be expected, all on the small side. The tolerance of the shaft is 0.001, so that the relationship between percentage of out-of-tolerance pieces and extent of out-of-tolerance in the worst pieces is estimated as 2.5 percent defectives and 0.0002 oversize on worst pieces.

The effect of the out-of-tolerance condition will be to reduce the oil-clearance allowance below the specified minimum in some of the assemblies. This will occur when one of the large shafts happens to be assembled with one of the holes in the bottom 0.0002 of the specification. It has already been shown that 2.5 percent of the holes are in the range. The probability, therefore, that the use of these large shafts will result in assemblies with below-specification oil clearance is 0.025 × 0.025 or 0.0006. There will still be 0.0003 oil clearance in the worst condition.

Table II—Code Letters

Sample Lot Size	Inspection Levels I*	II*	III*
2–8	A	A	C
9–15	A	B	D
16–25	B	C	E
26–40	B	D	F
41–65	C	E	G
66–110	D	F	H
111–180	E	G	I
181–300	F	H	J
301–500	G	I	K
501–800	H	J	L
801–1,300	I	K	L
1,301–3,200	J	L	M
3,201–8,000	L	M	N
8,001–22,000	M	N	O
22,001–110,000	N	O	P
110,001–550,000	O	P	Q
550,001 and over	P	Q	Q

*I—reduced; II—normal; III—tightened.

Relationship Between Factor Of Safety And Nature Of Process

The shaft just discussed cannot be assembled when its diameter exceeds that of the hole. Similarly, if the shaft is far undersized, it may not hold oil pressure when in operation. These inherent elements of self inspection are typical of many production processes. For example, if a forge shop were to ship a lot of steering knuckles having a quality level of 0.5 percent cracks, a serious condition would exist. The chances of using a cracked part are greatly reduced, however, because dozens of people handle these forgings in subsequent machining and assembly operations. The net result is that the shipment passes through many 100-percent inspections after it leaves the forge shop.

If a parts supplier has consistently maintained quality much better than the specified A.Q.L., it is reasonable to expect the next shipment from this source to be satisfactory. In such cases, a higher risk value can be utilized. On the other hand, if previous shipments have had a quality level above the A.Q.L., it will be necessary to tighten the inspection and reduce the risk value.

Quality Assurance At Stated Factor of Safety

Suppose that an A.Q.L. of 2.5 percent has been set and it is desired to determine if the process average is similar, significantly higher or significantly lower than this level. A large number of pieces, at least 1,000, would be inspected, and, allowing nothing beyond the gages, the number failing to conform fully to the specification would be counted. If more than four percent or 40 defects were found (Table I, upper limits), inspection would be tightened so as to reduce the risk of passing defective lots. Table I (lower limits) shows that less than one percent or ten defectives indicate a process significantly better than the A.Q.L.; thus making it safe to cut inspection to a reduced level. From 10 to 40 defects in the 1,000-piece sample would indicate that normal inspection should be used. Of course, different operating characteristic curves would apply in each case.

The sample plan for the inspection of a lot should take account of previous experience with the process average as well as the number of pieces in the lot. When inspecting a shipment of 100 pieces, it might be permissible to take a large risk, whereas, if a 100,000 piece lot is concerned, the risk should be lower. One procedure for making these adjustments between lot size, process average and sample size is illustrated in Table II. Tables III and IV are master charts for normal and tightened inspection, and reduced inspection, respectively.

To illustrate the use of these inspection plans, suppose that A.Q.L. of 2.5 percent has been set and study of a 1,000-piece sample from the process has shown the process average to be 3.1 percent or 31 pieces out of tolerance. This is within the expected variation from 2.5 percent for this sample and would therefore call for normal inspection of the material; i.e., level II.

If a lot of say 5,000 pieces is to be inspected, plan *M* would then be applied. Referring to Table III for code letter *M*, the first sample size would be 150. Following across in Table III for a normal inspection A.Q.L. of 2.5 percent, acceptance (AC) would be at seven, and rejection (RE) for 100 percent inspection at nineteen. The occurrence of more than seven or less than nineteen defectives requires a second sample which is specified in Table III as 300 additional pieces. In the cumulative sample of 450 pieces, acceptance can be with eighteen or less defectives, while rejection can be with nineteen or more.

If more than four percent defectives were observed in the 1,000-piece study, the expected variation from 2.5 percent would have been exceeded and tightened inspection be in order. This would be system *N* (Table III) and require first and second cumulative samples of 200 and 600, with acceptance at a maximum of nine defectives on the first sample or 24 defectives on a cumulative total of 600. Reduced inspection would be adequate if the process study revealed one percent or less out-of-tolerance pieces. This would indicate system *L*, Table IV, a sample of 30 pieces and acceptance at four or less defectives.

Table IV—Master Table For Reduced Inspection (Single Sampling Only)

Sample Size Code Letter	Sample Size	Acceptable Quality Level, percent																					
		0.10		0.15		0.25		0.40		0.65		1.0		1.5		2.5		4.0		6.5		10.0	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A, B, C, D	2	↓		↓		↓		↓		↓		↓		0	1	↓		↓					
E	2													0	1					1	2	1	2
F	3											0	1	↕				1	2	1	2	2	3
G	5									0	1	↕		↕		1	2	1	2	2	3	3	4
H	7							0	1	↕		↓		1	2	1	2	2	3	3	4	3	4
I	10					0	1	↕		↓		1	2	1	2	2	3	2	3	3	4	4	5
J	15			0	1	↕		↓		1	2	1	2	2	3	2	3	3	4	4	5	6	7
K	22	0	1	↕		1	2	1	2	1	2	2	3	2	3	3	4	4	5	5	6	8	9
L	30	↕				1	2	1	2	2	3	2	3	3	4	4	5	5	6	7	8	11	12
M	45	↕		1	2	1	2	2	3	2	3	3	4	4	5	5	6	7	8	10	11	13	14
N	60	1	2	1	2	2	3	2	3	3	4	4	5	5	6	6	7	9	10	12	13	15	16
O	90	1	2	2	3	2	3	3	4	4	5	5	6	6	7	9	10	11	12	14	15	18	19

↓ Use first sampling plan below arrow ↑ Use first sampling plan above arrow

Fig. 1—Apparatus employed in making the Norma-Hoffmann bomb oxidation test for the chemical stability of greases. Although a static test, data obtained agree well with service results.

Fig. 2—ASTM penetrometer for measuring the worked and unworked consistency of lubricating greases. The cone is dropped into the grease sample and the depth of penetration is measured.

Fig. 3—Bearing Engineers Committee grease testing machine for studying the mechanical stability and lubricity of grease. Torque measurements taken during test distinguish ordinary from low temperature greases.

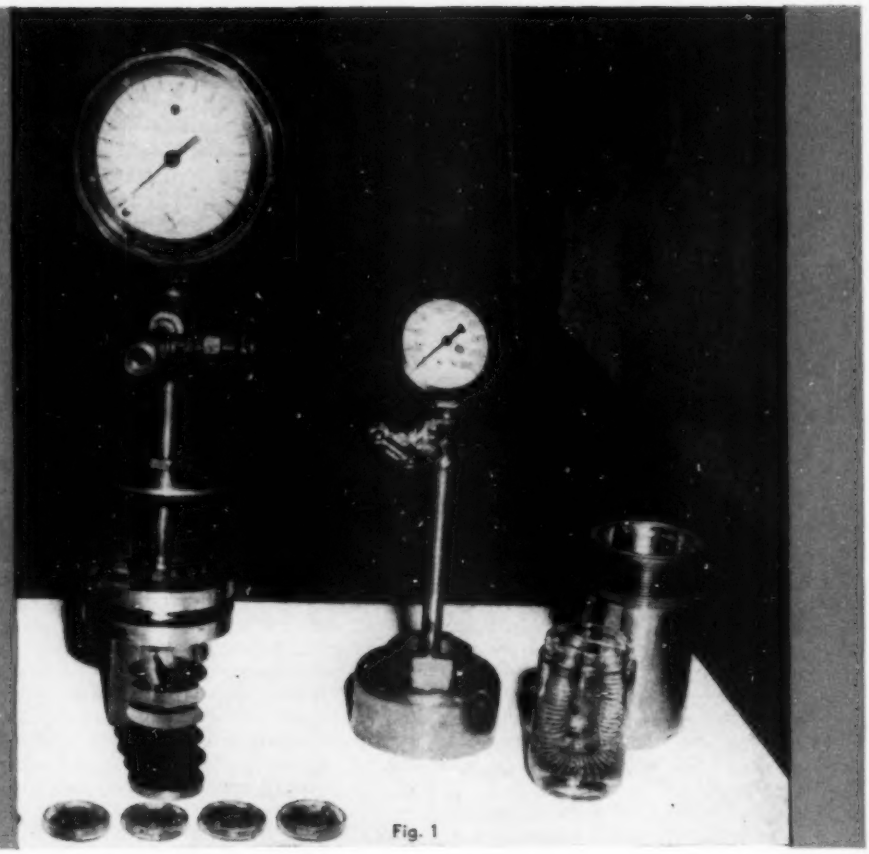


Fig. 1

Tests for Ball and

Laboratory test data that are significant in estimating the ability of ball and roller bearing greases to perform satisfactorily in particular services. Brief survey of testing procedures and their value in measuring mechanical stability, chemical stability, lubricity, and life properties of greases. Grease oxidation in oscillating bearings.

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Works Laboratory, General Electric Company

AS A RESULT of the widespread and numerous applications of ball and roller bearings throughout industry, test methods for evaluating the properties of ball and roller bearing greases are increasing in importance. Unfortunately, since there is not much agreement as to the relative value of the few existing standard tests, each lubrication engineer has his own way of evaluating the properties a grease should possess to assure a satisfactory performance of his machines.

The following discussion, therefore, is based only on the author's interpretation of the data obtained in the laboratory from the bench methods for evaluating greases.

When examining a sample of new grease, its consistency in both worked and unworked conditions should be measured first. In such a test, a standardized cone is allowed to drop in the grease at a definite temperature. The depth to which the cone penetrates is a measure of the consistency.

The unworked consistency test should be determined on the grease before it is removed from its shipping container, since work is done on it if transferred from one container to another. Grease is seldom received from the manufacturer, however, in a container that has been filled with grease in a semi-fluid state and then allowed to cool before shipment. The test, therefore, of necessity is made on grease in the "as received" condition, which may or may not have been softened by milling. Samples of ball and roller bearing greases in the "as received" condition vary from a hard penetration of about 130 to that of 350 on the soft side.

Grease for ball and roller bearing

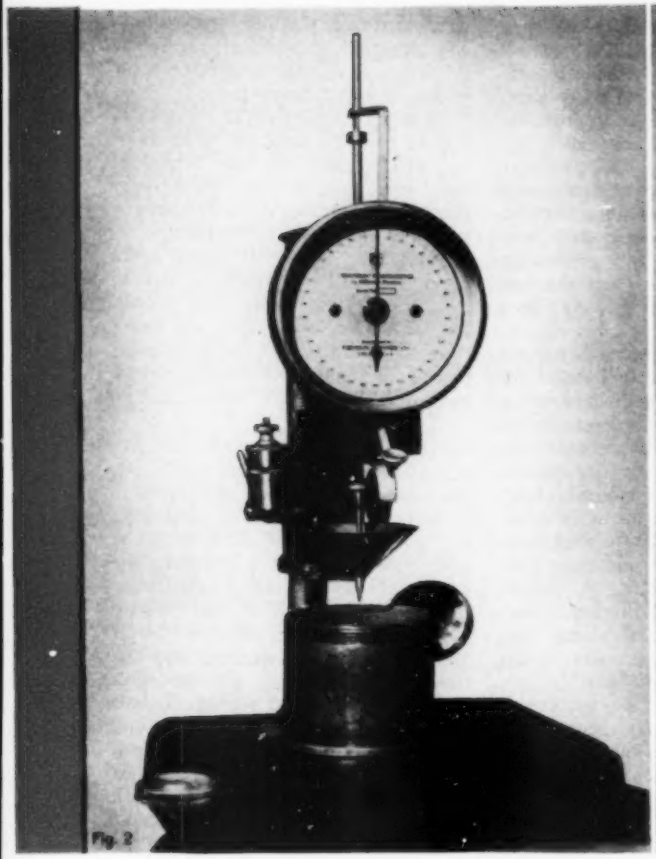

Fig. 2

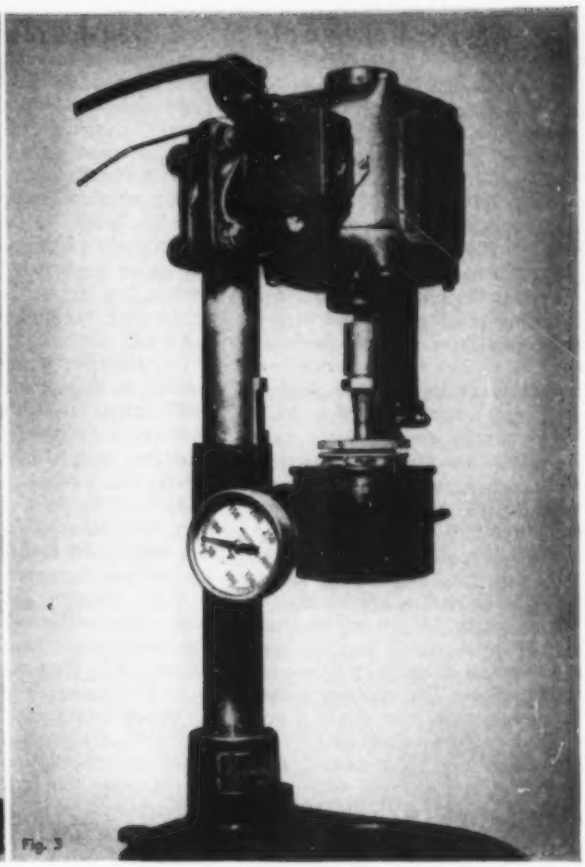

Fig. 3

Roller Bearing Greases

lubrication should be soft enough to be applied readily to the motor or machine with the filling equipment available. Many large plants employ power guns, but many small plants have only hand operated type guns. If too much energy is required of the man to force grease through a hand gun, the machine or motor may be lubricated only infrequently. The stiffest consistency for grease that will feed reasonably well through a hand gun is about 260 penetration.

It has been observed that some greases softer than about 320 will leak out of bearings. In these instances, the viscosity of the oil used in compounding the grease was not more than 300 seconds Saybolt at 100 F. A safe working range, therefore, is about 260 to 320. Greases stiffer than 260 have been used in industry with good success, but the author does not favor them. A range of about 260 to 290, or within the NLGI range of a No. 2 grease, is preferred.

Thinning of the grease in a bearing, of course, can also result when pressure is built up in the bearing by overfilling it and then failing to relieve the pressure by whatever drain is provided until running temperature is reached.

To be soft enough to prevent excessive wear between the rollers and the retainer, experience dictates that roller bearings need a grease of about 280 to 310 worked consistency.

In testing for consistency, the difference in unworked and worked penetration should be noted. If this difference is slight, the grease generally will remain mechanically stable in use.

In conjunction with other laboratory tests, the mechanical grease worker is a useful tool for measuring the mechanical stability of a grease.

A grease that has an unworked penetration of about 220 to 230 and softens on working 60 strokes to about 280 to 290 is likely to thin down much more under continued working in a bearing and eventually may leak out. If after 60 strokes with the worker, the penetration is more than 20 points softer than that of the unworked condition, it is good practice to check the grease thoroughly to make sure that it will not thin down too much in service and churn continuously in the bearing or leak past the seals on the shaft of the machine or motor.

Occasionally a grease becomes harder on working and this type may stiffen and channel in bearings to such a degree that sufficient lubrication is not provided and the bearing fails.

DROPPING POINT TEST. The dropping point of grease is the tempera-

ture at which it changes from a semi-solid to a liquid state. This test is one means of identifying the kind of soap or thickener used in making the grease. It is also a quick way of distinguishing between a petrolatum and a true grease, which usually contains some kind of soap.

Most petrolatums have dropping points of 105 to 115 F, and up to 140 F for a few special varieties.

Any soap thickened grease will have a dropping point greater than 160 F. Ordinary calcium soap grease ranges from 175 to 210 F. Aluminum soap greases average about 200 F. Lithium soap greases range from 350 to 390 F. Sodium-calcium soap greases range from about 250 to 350 F. Straight sodium base greases may run from 250 to over 550 F. Silicone greases range from 400 to 550 F.

These data do not mean that a grease will give satisfactory lubrication at temperatures approaching its dropping point. A calcium or aluminum soap grease is only good for about 150 F continuous and 175 F intermittent operation. The ordinary sodium or sodium-calcium base grease is good for 175 F continuous and 200 F intermittent operation in a motor. High temperature greases made with special soaps may be good for as high as 230 F. Silicone greases may operate quite satisfactorily at 350 F and for short periods at higher temperatures. The dropping point, therefore, is not a measure of the limiting temperature at which a grease may be used on the high side. But when used in conjunction with other tests, the dropping point gives useful information.

Qualitative determination of the soap base in a grease is easily accomplished by holding a platinum wire coated with the grease in a flame. A sodium base is readily detected by its strong yellow flame. Calcium alone is found only by burning off the grease on the wire, dipping it in hydrochloric acid to form a volatile chloride, and heating the wire again in the flame when a brick red color is obtained.

Lithium if present and uncontaminated by other soaps will give a carmine red flame that is easily detected. If sodium is also present, the yellow flame may mask the red of the lithium. In this event, a special filter glass is used to exclude the sodium rays. The glass recommended is No. 5120 Didymium filter glass. If only lithium (or lithium and sodium) is present, the flame will appear brilliant red when viewed through this filter and that color will persist for a long time.

Strontium soap will color the flame orange red. Barium soap imparts a yellowish green color, which remains for a long time; its color is masked if sodium is also present, but will remain after the sodium has been burned off. Copper soaps will also color the flame green. Aluminum soaps do not impart any color to the flames.

With the flame test, it is possible to determine quite easily what the soap base in a grease is. Based on a knowledge of the characteristics and limitations of each type, in conjunction with other tests, the engineer can readily pick the proper grease to do a given job.

For example, a sodium or sodium calcium base grease is well suited for ball bearings but it is soluble in water. It should not be used, therefore, in applications where water can enter the bearings and wash out the grease. With small amounts of moisture, however, the sodium soap forms an emulsion with water and may protect bearing surfaces from corrosion better than a water resistant grease. A sodium base grease withstands higher operating temperatures than a calcium base grease, but at temperatures below —20 F is generally not suitable.

Calcium base greases are inexpensive and are satisfactory for general applications where the lubrication required is not too exacting.

Aluminum soap greases have no advantage as a ball bearing grease.

Lithium soap greases are increasing in popularity, not only for low temperature applications but also as all-purpose greases. They are insoluble in water and withstand reasonably high temperatures.

Appearance of a grease is sometimes an aid to its identification. If the grease is clear and transparent, not opaque as most greases are, it is probably an aluminum soap grease or else one thickened with some of the newer non-soap additives. If sticky and stringy, it is either an aluminum soap grease or possibly a sodium soap grease made with an oil of high viscosity.

CHEMICAL STABILITY TESTS. As a rule, chemical analysis of grease furnishes little information of value to the engineer that can be translated into terms of useful life. The amount of free acid or alkali present, however, does give an indication of the possible chemical stability of the grease. In general, it is desirable that the grease be on the alkaline side for added stability, but there are greases on the acid side that are very stable.

Spurred on by military requirements for highly stable greases, the property of chemical stability, or resistance to oxidation, is becoming increasingly important. Today most high grade greases contain anti-oxidants, which have increased stability many times. The accepted method of measuring the chemical stability of greases is the Norma-Hoffman bomb test.

At a temperature of 210 F greases may be badly oxidized in 50 hours or may still be stable after 500 hours. In the harder consistencies, these latter highly stable greases are in demand for sealed or double shielded bearings.

While the bomb test does agree reasonably well with results in service, it is a static test. Since most greases are in motion while they are being churned and oxidized in a bearing, there is a trend toward the development of a dynamic oxidation test.

HIGH AND LOW TEMPERATURE APPLICATIONS. Soap content, water, fat, glycerine, and fillers are of value only to grease manufacturers in controlling the quality of their products. The viscosity of the oil used in making the grease may determine the temperature range within which it will operate satisfactorily. Some of the better greases for high temperature applications are made using oils having a viscosity of over 500 seconds Saybolt at 100 F. If the viscosity is over 1000 seconds Saybolt at 100 F the grease is not likely to give satisfactory lubrication at ambient temperature of —10 F and lower.

The problem of determining the suitability of a grease for high temperature applications can be approached quite simply by packing the grease in open Conrad type bearings and placing them on watch glasses in a warm oven. In this test the temperature of the oven is raised in steps of 10 deg C. After the bearings have soaked at a step for 24 hours, they are removed from the oven and cooled down. Any free oil, hardening, drying out, or oxidation of the grease is noted, and the bearings are tested for freedom of motion.

If the grease seems unchanged, the bearings are replaced in the oven and the temperature stepped up. If after a step a significant change in the grease is noted, the bearings are replaced in the oven and soaked at that step temperature for a week to produce the worst possible change. This test does not duplicate what the grease would do if agitated in a bearing at a given temperature, but serves as a rough guide as to what might be expected.

No universally standard procedure is available at the present time for measuring the torque required to spin a bearing at sub-zero temperatures. Its measurement is being studied intensively but correlation of results is difficult. Satisfactory low temperature greases can be selected, but no accurate

measure made of how superior one is to another for sub-zero operations.

GREASE LUBRICITY. The Bearing Engineers Committee grease testing machine, developed some years ago, is used infrequently today at least in its original form. This machine, however, is a valuable laboratory tool.

At the beginning of a test, a No. 204 bearing single shield with shielded side down is packed to its capacity with grease, the grease levelled off flush with the sides of the races, and then carefully weighed. The temperature of the surrounding oil bath at the start of the test is carefully noted, and the test is run at room temperature for one hour. The rise in temperature of the oil bath during the test gives a rough idea of the lubricity.

A grease that has good lubricating value will give a temperature rise of only 10 to 15 deg F over the initial starting temperature. A poor lubricant may give a 35 to 40 deg F rise.

Starting and running torques and appearance of the grease are also noted. In general, the lower the starting and running torques, the cooler a bearing will run. Although torque measurement is made at room temperature, it will quickly identify a low temperature grease. Where an ordinary grease will have a starting torque of 700 to 1200 or more gram centimeters and a running torque of 250 to 400 gram centimeters, a low temperature synthetic diester grease will have starting and running torques of less than 200 gram centimeters.

These data reflect the viscosity of oil used in making the grease. A low temperature grease may contain an oil of only about 60 seconds Saybolt viscosity at 100 F, whereas, an ordinary grease may be made with oils ranging from 300 to over 2000 seconds Saybolt at 100 F. Those greases containing high viscosity oils, of course, will give high torques and cause the bearings to run warmer.

Some greases stiffen after a few minutes operation at room temperature and channel.

With the ordinary grease, of course, there is no leakage through the shield at room temperature, but some grease may be thrown up out of the bearing and cling to the shaft above the bearing. Within the consistency range of about 260 to 320, most of the grease remains in the bearing. If the grease is harder than 260, as much as 40 to 50 percent may be thrown out. If softer than 320, the grease may leak through the bottom shield of the bearing into the cup below. Such a grease might leak past grease seals in a motor and either come out along the shaft or get in on the windings.

FRICTION OXIDATION. This type of oxidation is only troublesome where bearings are subject to slight oscillations or movements, such as are encountered in control bearings on planes, or in automobiles and motors while being shipped across the country. The oxide formed is Fe_3O_4, which is black and magnetic; not Fe_2O_3, the ordinary red brown oxide.

The Fafnir friction oxidation test machine is useful in selecting a grease that is resistant to friction oxidation. Although the standard test calls for a load of 550 lb on the test bearings, which are Fafnir No. 4J05 thrust bearings with grooved rims, the author has obtained better results with a 900 lb load.

In general, greases with low viscosity oils show up well on this test. Some of the lowest wear occurs with the synthetic diester greases. There is also some indication that the presence of a good antioxidant in the grease is helpful in preventing the oxidation of iron to its magnetic oxide in the friction oxidation process. The Fafnir test also shows that the presence of some extreme pressure additives causes a greater amount of wear on a bearing.

No standard test has been accepted to determine the ability of extreme pressure greases to stand up under heavy loads, but the Shell four ball tester has been used for this purpose. In general, good extreme pressure greases will stand about 1700 lb load in an adaptation of the Falex machine, designed to test extreme pressure properties, as compared with 900 to 1000 lb load for an ordinary grease.

OIL LIBERATION. Bleeding of oil from grease standing in containers or in service is a property that is subject to considerable controversy. Grease, of course, must liberate a certain amount of the oil from the soap structure to insure good lubrication. The reference here, however, is not to the normal amount of oil a good grease liberates, but to excessive pools that may form on the surface or bottom of a container. The author contends that no free oil should be visible, its presence indicates poor compounding.

TESTS FOR SYNTHETIC GREASES. With the coming of the newer synthetic diester and silicone greases, tests to distinguish between these types of greases should be of increasing importance. While they are advocated either for low or high temperature work, no standard methods have been approved covering the identification of these greases. The current procedure at the Schenectady Turbine Division Laboratory of the General Electric Company is described in "Tests that Distinguish Types of Lubricating Greases", published in the *G. E. Review,* August 1949. These are employed in checking for low temperature applications. They will distinguish greases made from petroleum oils, from synthetic aliphatic diesters and from silicones.

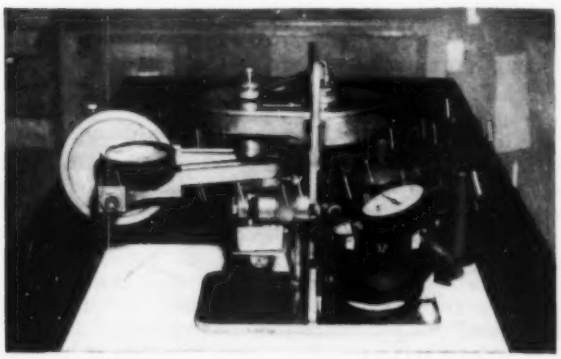

Fig. 4—Fafnir friction oxidation machine for selecting a grease that is resistant to oxidation in bearings that are oscillated.

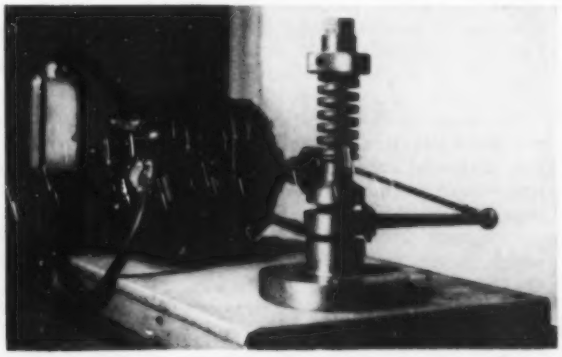

Fig. 5—Falex machine for testing the load carrying capacity and extreme pressure properties of oils and greases.

Compound Characteristics from Shunt Wound Machines

H. D. JAMES
Consulting Engineer

GOOD SPEED CONTROL or load protection can be obtained by regulating the field of a standard shunt wound machine with a magnetic amplifier. This combination of motor and control can be used in place of compound wound machines in applications requiring either constant speed or constant load performance.

To obtain optimum regulation of a compound motor, different amounts of series field are required for various types of load, even if the load ratings are the same in each case. Thus bending roll drive motors are heavily compounded, while in normal machine tool power units the compounding is usually a small percentage of the total field. This often results in the use of a compromise winding, with different shunts around the series field. These shunts are difficult to adjust.

In contrast, a shunt motor with magnetic amplifier field control will give good speed or load regulation regardless of the characteristics of the load. This type of speed regulation is particularly good when motor speeds must be closely matched, as in a continuous mill.

CONSTANT SPEED MOTOR CONTROL

The speed of a shunt motor decreases with an increase in load. When a series field is added it opposes the shunt field. Motor speed can be kept nearly constant for a limited load range because the field strength is reduced on increasing loads and increased under light loads. Compounding is difficult to adjust for accurate speed control, since any adjustment must be made by adding a shunt across the series winding. The resistance of this shunt is so low that it can be affected by variations in contact pressure and temperature. A more versatile and accurate speed control is shown in Fig. 1, where motor field strength is regulated by means of a magnetic amplifier instead of a series field.

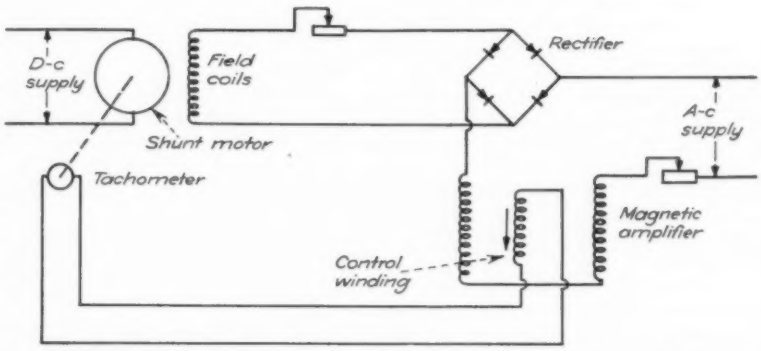

Fig. 1—Magnetic amplifier speed control of shunt wound motor. Tachometer generates a d-c voltage in direct proportion to motor speed. Rectifier output is controlled so that field strength varies in the proper manner to maintain constant speed.

The motor field is energized by the rectifier through a variable resistor. The magnetic amplifier regulates the power input to the rectifier. Amplifier impedance depends on the flow of direct current in its control winding which in turn varies with the output of the motor-connected tachometer. An increase in motor speed increases the tachometer output and control winding field strength. The amplifier core iron becomes more nearly saturated and allows a greater flow of alternating current to the rectifier. This increases the motor field strength and reduces the speed to the desired value.

A decrease in motor speed reduces the amplifier flux and motor field, causing the speed to increase to normal.

The flux in the amplifier core iron is kept close to the bend in the magnetizing curve. Therefore, a small change in control coil strength causes a large variation in magnetic flux and amplifier impedance. A 1 percent change in coil strength will vary the motor field strength by 10 to 100 percent or more, depending on the application.

Another control arrangement, Fig. 2, makes use of the fact that for constant speed the field strength is inversely proportional to the load. No tachometer is necessary.

The system is similar except that amplifier impedance is controlled by two coils instead of one. Coil V is

connected across the motor leads and gives a constant saturating reference flux. Coil *A* measures the load by the voltage drop across the interpole motor windings and generates a flux in opposition to the reference flux.

An increase in load causes a decrease in speed and a greater drop across the interpole windings. The flow of current in coil *A* increases and causes a reduction in saturation of the magnetic amplifier core iron. This weakens the field and the speed returns to normal. Speeds lower than the desired value have the opposite affect. The reference flux and consequently the control point can be set by adjusting the variable resistor.

This arrangement is not as accurate as that shown in Fig. 1, but gives satisfactory regulation for hoist and elevator applications.

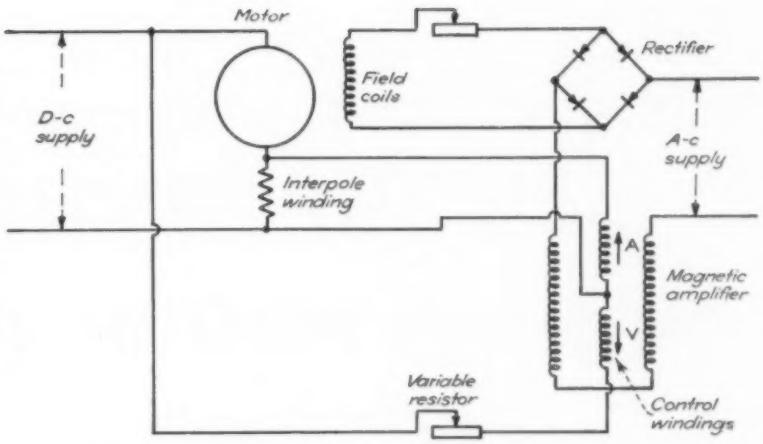

Fig. 2—For constant speed operation, the field of a shunt motor is inversely proportional to load. This circuit uses this principle by controlling the output of the motor field rectifier in inverse proportion to the drop across the interpole windings.

CONSTANT LOAD MOTOR CONTROL

Compound wound motors are also used to maintain constant motor load. For these applications the series winding strengthens the shunt field and reduces motor speed as the load increases. This decreases the work done by the motor and maintains a constant load. When the load is less than normal, the series winding decreases field strength and increases motor speed. Magnetic amplifier control of a shunt motor, Fig. 3, gives similar but more accurate control.

The load is measured by the voltage drop across the interpole motor windings. Since the saturation of the amplifier iron is directly proportional to the load, only one control coil is required. When the load increases above normal, amplifier current is increased. Motor load and speed are reduced. A decrease in motor load weakens its field to increase its speed and restore the load to normal.

For larger motors, amplifier size can be reduced by using two motor field windings. One field is manually adjusted for full load speed and a smaller field is controlled by the amplifier to obtain speed or load regulation.

Besides achieving a reduction in the physical size of the magnetic amplifier, this arrangement also permits the use of units which are more sensitive and have higher response speeds. This results in overall better control of the motor field.

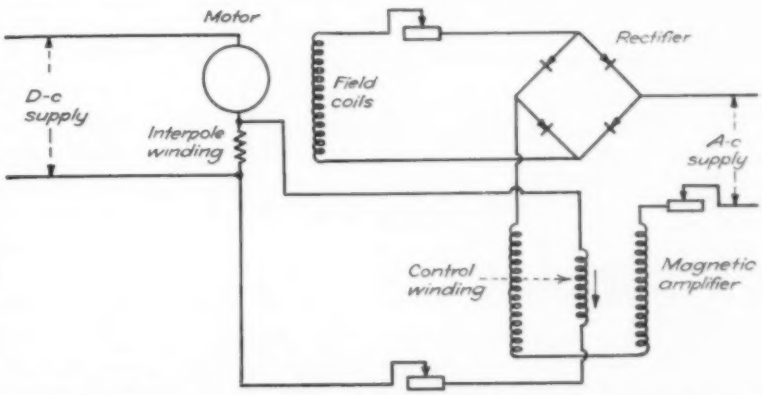

Fig. 3—Shunt wound motor with magnetic amplifier field control for constant load. Output of amplifier and field rectifier varies with the drop across the interpole windings. Variable resistors in circuit permit adjustment for desired constant load.

GENERATOR CONTROL OF SPEED

When a shunt wound motor receives its power from an individual shunt generator, motor speed can be regulated by controlling the generator field, Fig. 4. This is similar to direct motor field control except that generator field strength varies directly with generator output, instead of inversely as in a motor.

The generator field is energized by rectifier *C*, the output of which depends on the impedance of the magnetic amplifier a-c windings. Control coil *V* gives a saturating reference flux and is adjusted so that the control point falls near the bend of the magnetizing curve. The flux generated in the nonsaturating winding *S* varies with the output of the motor connected tachometer. Motor field strength is maintained constant for a specific control point.

If motor speed is above the desired value, control winding *S* increases the impedance of the magnetic amplifier. The generator field strength is decreased and the motor slows down. At speeds below normal, winding *S* increases the amplifier core saturation and the generator output increases. This system of motor speed control is used where close speed regulation is required, such as for continuous strip

steel mills and sectional paper machines.

Another method of controlling motor speed by magnetic amplifier compounding of shunt wound generators is shown in Fig. 5. No tachometer is required, and generator load is measured by the drop across a fixed resistor in the armature circuit. For a constant motor field strength, motor speed varies inversely with load.

Control coil *V* gives a field saturating reference flux. When motor speed decreases because of increased load, the flow of current through coil *A* increases. Generator field excitation increases and motor speed is brought back to normal. If the load is negative (tends to drive the generator), the flux of coil *A* reverses and opposes the reference flux. This causes a reduction in generator output voltage so that the motor can return power to the line through the generator. The breaking effect maintains constant speed under overhauling loads. Accurate speed control of hoists and elevators can be obtained with this circuit, even with large variations in load.

The general principle of magnetic amplifier compounding of shunt wound machines can be applied to any new or existing shunt motor. This may sometimes relieve the necessity of carrying compound wound motors and adjustable series field shunts in stock. Under any condition, magnetic amplifier control gives closer load or speed regulation than can be obtained by using a series winding for compounding.

The present trend in power supplies, for drives which are used to control load or speed, is away from a-c and towards d-c. As the use of d-c increases, these methods of controlling d-c machines are becoming important.

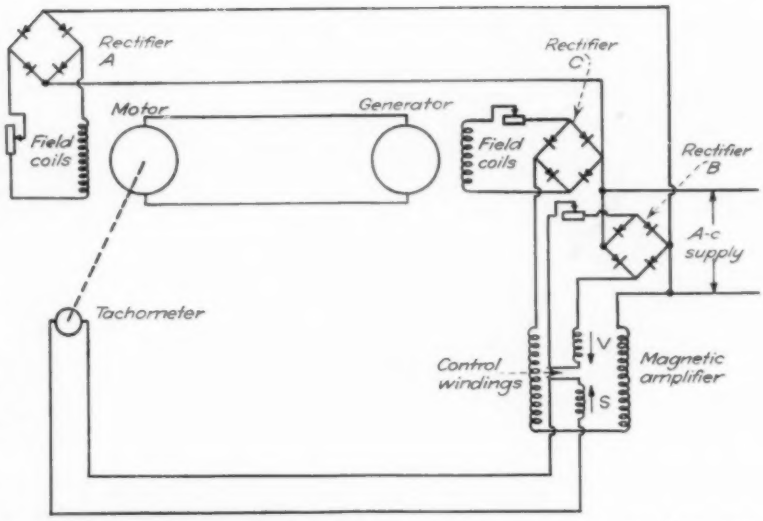

Fig. 4—Individual generator drive of a shunt wound motor. Constant speed operation of the motor is obtained by regulating the control magnetic amplifier and the generator field in accordance with the signal output of the motor-connected tachometer.

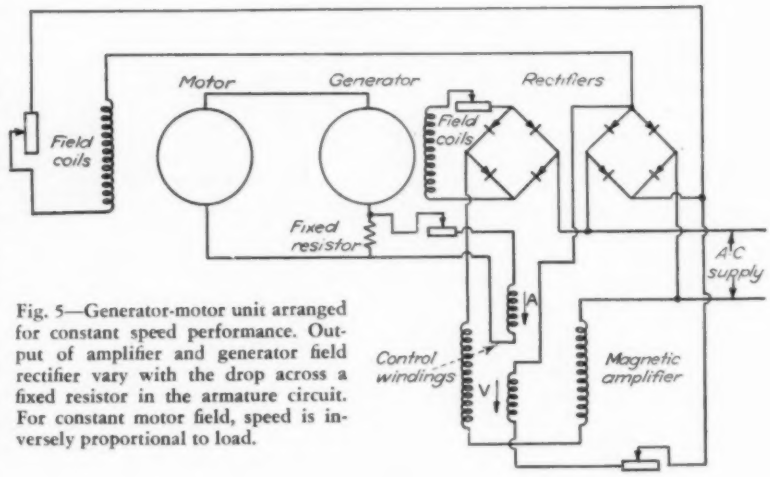

Fig. 5—Generator-motor unit arranged for constant speed performance. Output of amplifier and generator field rectifier vary with the drop across a fixed resistor in the armature circuit. For constant motor field, speed is inversely proportional to load.

Tailor-Made Oils For Special Lubrication Problems

FOR SPECIAL APPLICATIONS where petroleum products do not function well, scientists are developing synthetic oils to obtain optimum advantages. Typical of these are the aliphatic esters, polyalkylene oxides, the silicones, esters of phosphoric and silicic acids, and highly fluorine-substituted hydrocarbons. Some of these are now commercially available and volume up.

However no one of these synthetics is best for all purposes. Physical, chemical and economic requirements peculiar to each lubrication problem determine which lubricant to use.

The synthetics have certain inherent advantages over mineral oils: (1) since they are homogenous in the chemical sense, engineers can predict and control all of their properties; (2) chemical addition agents can be used to improve them; and (3) development of compounded oils is simpler because there are no undesirable chemicals present to cause variations from one production batch to another.

Major impetus behind the development of these lubricants has been the need for lubricants at very low temperatures (to —65F) and at considerably higher than usual temperatures. Advantages of the new materials include: low freezing points, low evaporation rates, excellent oxidation resistance, stability, nonflammability, and excellent response to inhibitors and oiliness additives.

On the other hand, the synthetics may display a deleterious effect on some plastics, paints, and rubber. Silicones have limited oiliness properties.

Continued developments are underway to extend the storage and operating life of the new oils as well as their operating temperature ranges.

PROSPERITY IN THE USA: How Deeply in Debt Are We?

How prosperous *are* the people of the United States? Previous messages in this special series have answered this question in part by recording the progress—relatively slow progress—we have made in increasing both the income and the wealth per person in the USA.

This fourth and concluding piece of the special series deals with the extent to which our prosperity should be discounted because it has been accompanied by an increasing volume of debt. Many correspondents have suggested to us that an individual or a nation can temporarily increase prosperity by borrowing, but in so doing lives on both borrowed goods and borrowed time. Our purpose here is solely to throw light on the question of whether or not we are now in that unenviable position.

On January 1, 1953, the total debt of the United States government and of its citizens was $627 billion, as shown in the table below. On its face, a debt of this magnitude, which represents about $3,900 of debt for each person, suggests that we are heavily debt-ridden.

TOTAL DEBT – PUBLIC AND PRIVATE

Federal government debt	$267 billion
State and local debt	30 "
Private debt	
Corporations	195 "
Individuals	135 "
	$627 billion

The burden of our debts, however, does not depend simply on their size. It depends in much more decisive degree on our capacity to carry the load successfully. This capacity, in turn, is partly a matter of attitude, and attitudes defy objective measurement. A community that gets very jittery about its debts has less capacity to carry its burden successfully than one that does not. But the accurate measurement of jitters, present or prospective, still remains to be mastered.

Capacity to Carry the Debt Load

Nonetheless, it is possible to throw some light on our capacity to carry the debt burden by studying key economic elements that can be measured with some degree of accuracy. The following paragraphs indicate how some of these key economic elements stand.

Compared with our national income, the total volume of our debts, public and private, is still well below the level of 1929, when it proved to be too big for the good of the country. Our total debt is now 113% greater than the national income whereas in 1929 it was 146% greater.

There are several other cheering facts about our debts. One is a sharp decline in interest rates which makes the cost of carrying our debts relatively much less than it was in 1929. It took 8% of our total national income to carry our debts in 1929; it takes only about 5% of the income today.

More Cheering Facts

We also have much more ready cash now than in 1929. Today individuals and corporations hold a total of $269 billion in cash or its equivalent which is almost twice as much as the portion of private short-term debt (about $140 billion) that is subject to sudden demand for payment.

Many students of the subject cite the relatively low cost of carrying our debts and the large volume of cash on hand, and reach the comfortable conclusion that our debt burden is nothing to worry about. In further support of this view they emphasize the fact that no important part of our debt is owed abroad. Hence, they reason there is not the danger, so conspicuous in Britain since the end of World War II, that our economy will be upset by the necessity of making heavy debt payments to other countries.

Some Dangers of Present Debt

However, the nature of our debts presents dangers that it would be foolish to ignore. This is true of both the debt of $267 billion owed by the federal government to its citizens and the $330 billion in private debts owed by some citizens and corporations to others.

Public debt can be a dangerous kind of debt because government has the power to print money or to create its equivalent by expanding bank credit. Of the $215 billion that the federal government borrowed during World War II, over $90 billion was borrowed from banks. This was the largest single contributor to the inflation of prices that since the war has robbed the dollar of about half of its purchasing power, and thereby robbed the buyers of government bonds of about half the purchasing power these bonds were supposed to represent.

If, as is quite possible, a new emergency should again require the federal government to borrow heavily while its debt remains so high, it is doubtful that the public would be avid to buy its bonds. Hence, the government might again be forced to resort to the inflationary process of relying on bank credit.

Private debts can be dangerous if the people take on new debts more rapidly than is justified by the growth of business or by their ability to repay. Last year bank loans were increased by the imposing sum of about $6½ billion, which represents an increase of about 11% in total loans outstanding. This is almost twice as much as the increase in the volume of business over the same period. Installment credit for consumers increased by $3 billion last year, again an increase in debt about twice as great as the increase in business volume in the fields where the credit was used. It is also the fastest rate of such growth in our history.

Constructive Use of Credit

So long as the expansion of credit does no more than keep pace with expansion in the volume of business, the expansion is constructive. Also, when credit is expanded to acquire resources and equipment that will enlarge the volume of business a little later, that use is clearly constructive. But when private credit expansion begins to run ahead of business growth, it is time for us to be heads up. Such credit expansion courts price inflation. It also creates a forced draft under business so that, if credit is cut off, there may be a painful drop.

To give a summary answer to the question: *Is the level of debt in the United States a danger to our prosperity?* — the answer seems to be, "Not at the moment." We owe nothing abroad. The interest burden on present debt is relatively small, and we appear to have the resources to handle the short-term debt. Yet both the total amount of debt and the recent rapid increase in total private debt, especially the latter, are enough to signal for caution. We need restraint on the part of business and consumers to avoid expanding private borrowing at an excessive rate. The federal debt needs to be reduced and put in more manageable form. If these things are done, we can proceed to build a sound prosperity.

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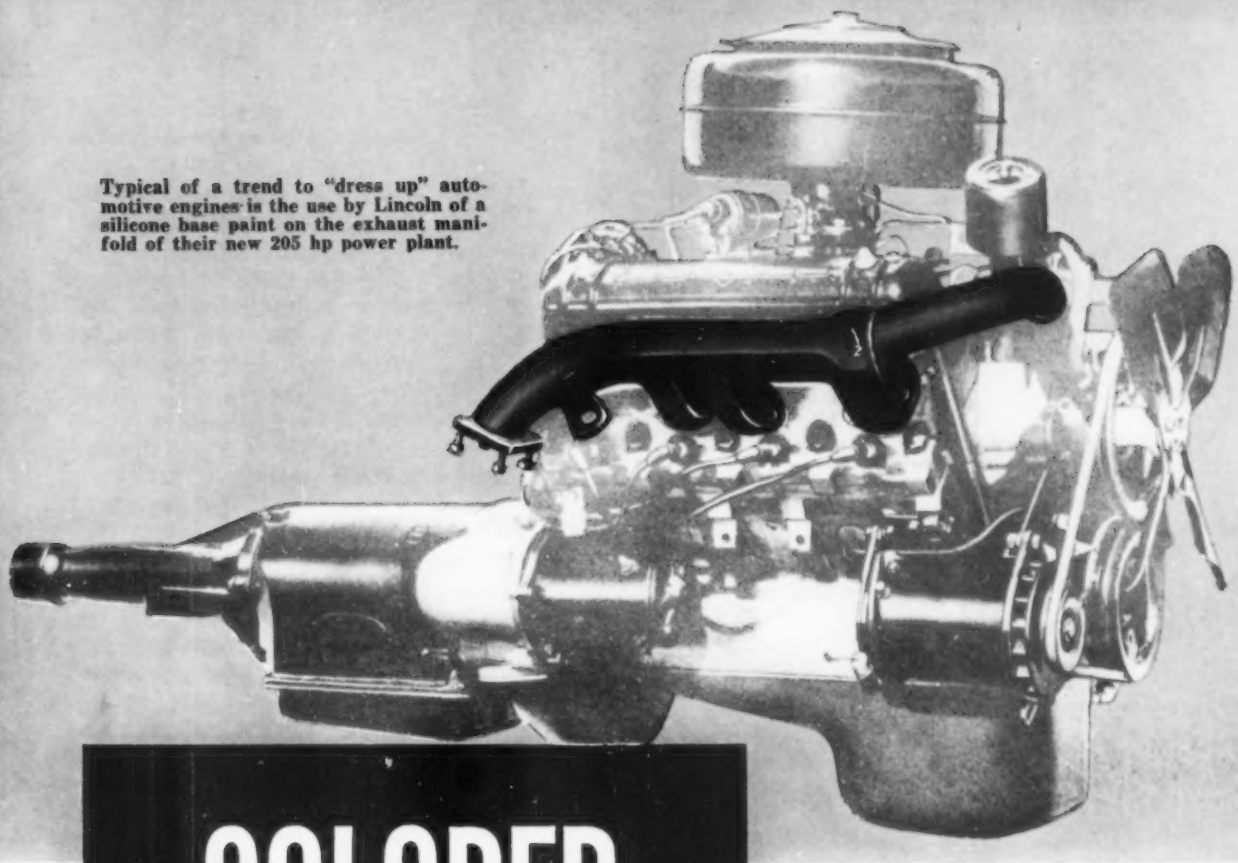


Typical of a trend to "dress up" automotive engines is the use by Lincoln of a silicone base paint on the exhaust manifold of their new 205 hp power plant.

COLORED SILICONE FINISHES

Properties of colored, heat-resistant silicone finishes . . . Comparison with alkyd-melamine base enamels . . . Recommended applications for various classes of industrial equipment and consumer products.

M. A. GLASER
Chief Chemist

E. MILLER
V. P. and Technical Dir.
Midland Industrial Finishes Co.
Waukegan, Ill.

THE SUCCESSFUL development of silicone coatings in color opens up significant new fields of application for designers and engineers throughout the metalworking industry.

Aluminum and black pigmented silicone coatings for purely functional use are well established and are being applied where resistance to high temperature previously was a major problem. In many cases they have superceded older conventional finishes. On such products as exhaust stacks, boilers, engines, heat exchangers, mufflers, stove parts, and aircraft components, silicone finishes with aluminum pigments have withstood corrosive atmospheres and temperatures in excess of 1,000 F while maintaining good film integrity and appearance. Black finishes, based on silicone resin, similarly have been field tested and approved for use on engine manifolds, heaters, photographic equipment, exhaust systems and heat exchangers.

The addition of black or aluminum pigments keeps pace with the heat and chemical resistance of the silicone vehicle, and frequently enhances

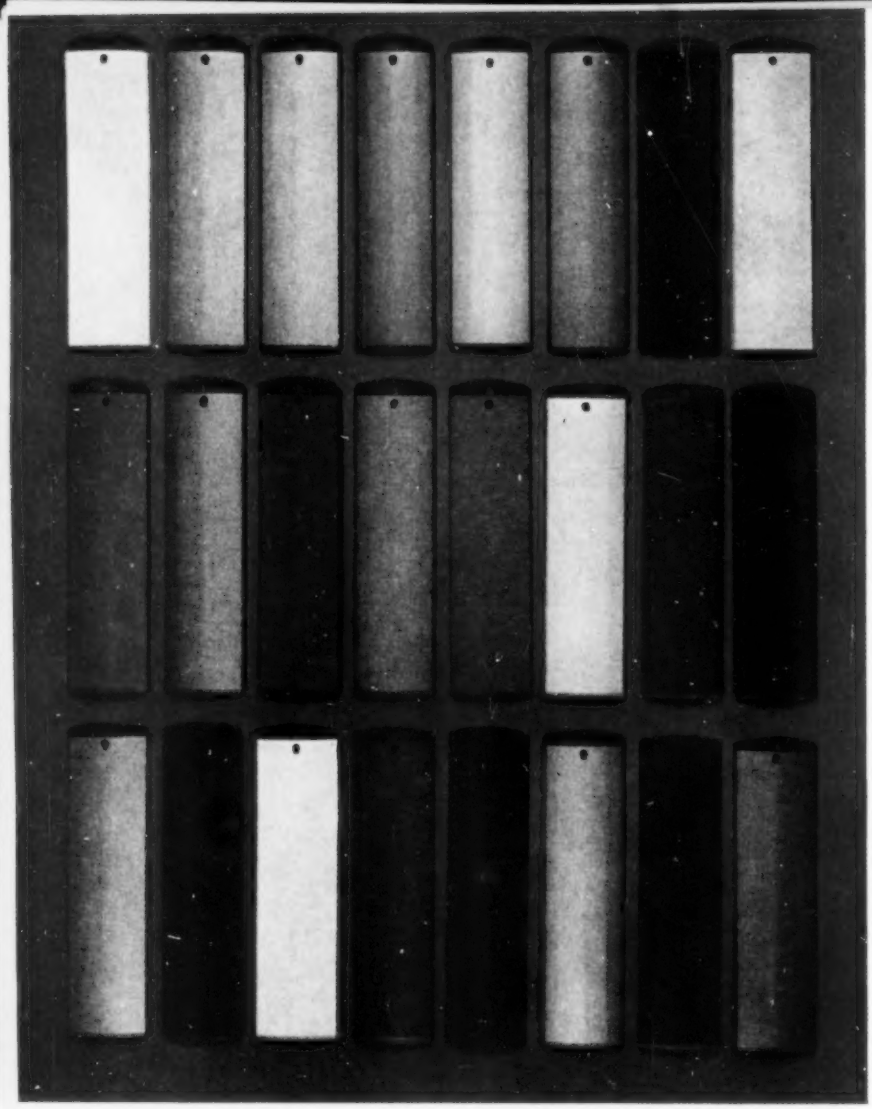


Fig. 1—Colors that are available in silicone base finishes. Although somewhat less heat resistant than aluminum or black pigmented vehicles, these types can be used between 350 and 1,000F without significant changes in color.

those properties; special grades of aluminum flake and black pigments can withstand elevated temperatures up to 1,500 Fahrenheit.

Silicone base vehicles pigmented with other colors Fig. 1 are not as heat-resistant as the above types but do, nevertheless, compare favorably with conventional finishes, and their use on a wide variety of products where decorative appeal has hitherto been difficult is now a distinct and practicable possibility. They fill an important niche between conventional finishes and inorganic (porcelain or ceramic) materials. For the purposes of this article, conventional finishes are considered as those based on oleoresinous varnishes, alkyd, urea-formaldehyde, melamine-formaldehyde, triazine formaldehyde, vinyl, rosin, acrylic, cellulose solubilized rubber, terpene and hydrocarbon resins. The conventional finishes have limited heat resistance, usually failing under 400 F. Inorganic finishes are generally satisfactory for heat resistance in the 1,000 F to 2,000 F range. Silicone enamels are most useful when the exposure environment is in the 350 F to 1,000 F region. In Table I is a

Fig. 2—How a non-pigmented silicone vehicle (top) compares with an alkyd melamine vehicle after exposure at room temperature, 500F, and 575F. Note change in color and gloss of the melamine, and relative stability of the silicone. This gives some idea of base metal protection.

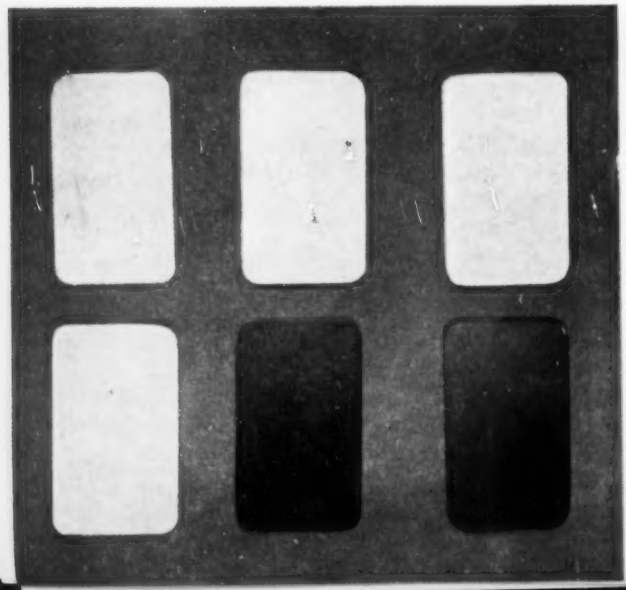
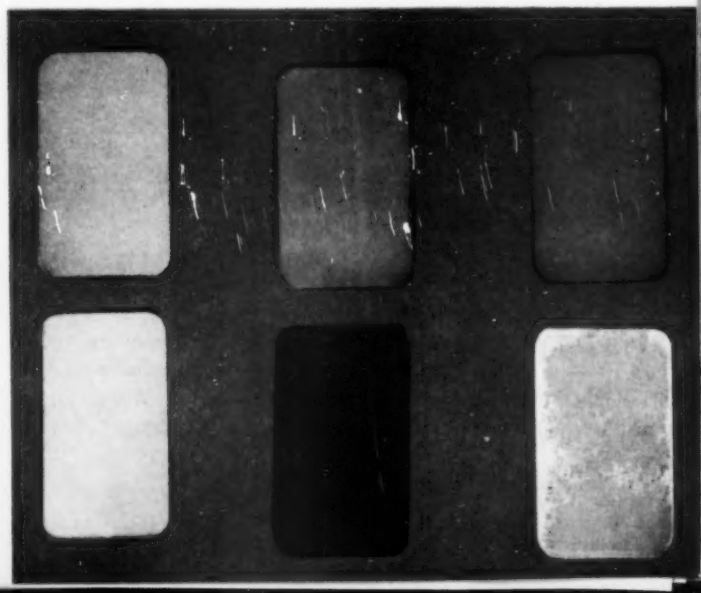


Fig. 3—Effect of temperature on color and film integrity of gold pigmented silicone finish (top panels) and conventional base finish. After exposure to 450F for 15 minutes (left) both finishes are still satisfactory, but after exposure at 500F and 575F, the non-silicone volatilizes.



comparison of these three general classes of finishes.

A glance at Fig. 2 illustrates what happens when just the vehicle portion of a heat resistant silicone finish is compared with a good alkyd-melamine vehicle after exposure at elevated temperatures. Although both materials start with good film integrity, pale color and high gloss, the alkyd-melamine discolors badly at 500 F., loses gloss, and changes from a water white to a charred black film. The change at 575 F is even more severe, with film properties being so poor as to offer no protection. The silicone vehicles, however, goes through both the 500 and 575 F. exposure with no appreciable change in color and gloss.

In general, silicone vehicles have good chemical resistance, Table II. With the exception of organic solvents, they withstand most reagents including acids, alkalies, salts, and oils, exceptionally well.

Silicone paints are applied by conventional methods such as spraying, dipping, brushing, and roller-coating. Primers are not customarily required, but a good degreasing operation and/or a light phosphatizing treatment are recommended before the application of the finish. No essential changes in spray equipment, production techniques, or ovens are necessary. In some instances, advantage can be taken of the silicone's heat resistance properties to shorten baking schedules by raising oven temperatures 50 to 100 F beyond those formerly deemed safe with conventional old line coatings.

Formulation of Coatings

The pigments used in coloring silicone enamels must be chosen carefully, with reference to the end use of the enamel. Fortunately, the finish development engineer has at his command a selection of pigments that possess not only excellent heat resistance, but also fine chemical resistance and durability. Organic pigments do not usually have the thermal stability required for high heat silicone paint applications. The phthalocyanine blues and greens are exceptions to this rule and may be used for many applications. Many inorganic pigments may be employed with silicones to get substantially the same range of colors that are offered in conventional finishes. Some of these pigments are: cadmium sulfide yellow, cadmium sulfo-selenide oranges and reds, cadmium selenide maroons, titanium dioxide white, cobalt oxide blue, chromic oxide green and yellow and red iron oxides. The higher cost per hiding unit of some of these pigments is noteworthy. For example, the pigment cost in a silicone red baking enamel may be 3 to 5 times that of an orthodox red baking enamel of approximately the same color.

Where the temperature requirements are not so severe, low priced silicone modifications are available. These have been made in a limited color range—grays through most shades of brown and tan, to some blues, greens and reds. For severe temperature requirements, higher priced silicone enamels may be made. These can be had in white, ivory and other colors.

Thus, in the formulation of silicone vehicles for specific end-uses, the paint chemist will try to use the lowest silicone resin ratio that will give his customer the required performance characteristics. The reason for this is readily understood when the respective costs of silicone and most other organic resins are studied. Silicone resins and oils cost $3.50-$6.00 per lb (based on 100 percent resin) while potential modifiers come in the less-than—$1.00 per lb category on the same basis. Thus, low-cost silicone vehicles may contain 1 part silicone resin to 5 parts modifier; moderately-priced vehicles, equal parts of silicone and modifying resin; and high-priced silicone materials 90-100 percent silicone resins.

Modifiers which are useful in conjunction with the silicone resins include the following resins: alkyds, amines, chlorinated diphenyls, acrylics and hydrocarbons. As would be expected, the low-silicone content finishes lack

Fig. 4—Vehicle heater, manufactured by the South Wind Division of Stewart Warner for military use is finished with an olive drab silicone coating. This coating, which must withstand much higher temperatures than required in civilian applications, has a salt spray resistance in excess of 300 hr. after exposure to 500F for four hr. Heaters represent an excellent use of silicones.

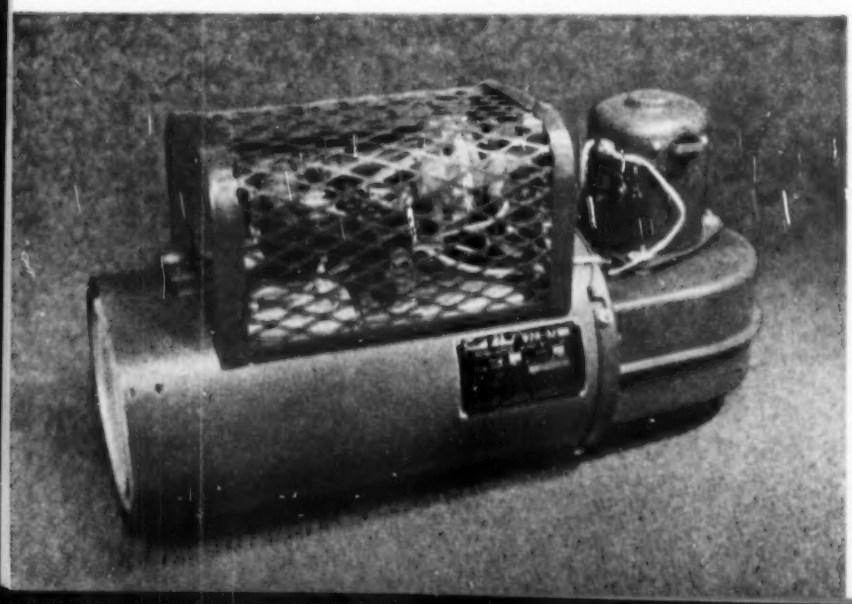


TABLE I
PROPERTIES OF CONVENTIONAL, INORGANIC AND SILICONE FINISHES*

Properties	GENERAL CLASSES OF FINISHES Conventional	Inorganic	Silicone
Hardness	Good	Excellent	Good
Abrasion resistance	Good	Excellent	Good
Resistance to mechanical and thermal shock	Fair—Good	Fair—Good	Good
Resistance to moisture	Very Good	Excellent	Very Good
Chemical resistance	Good	Good	Good
Resistance to weathering	Good	Very Good	Good
Heat resistance, F	400 max	Approx. 2,000 max	Approx. 1,000 F max
Repairability	Good	Poor	Good
Damage during manufacture, shipping and installation	Normal	High	Normal
Cost of curing or firing (including capital investment on ovens)	Normal	High	Slightly above normal
Substrate cost	Normal	High	Normal
Finish cost per sq. ft.	Low	High	Moderate

** Based on typical properties. Does not refer to specific finishes or colors.*

TABLE II
CHEMICAL RESISTANCE OF WHITE SILICONE COATING

Chemical Reagent	Rating after Immersion at 70 F 3 hr	20 hr	100 hr	Rating after Immersion at 100 F 3 hr	20 hr	100 hr
Acetic acid, 2 percent	E	E	E	E	E	E
Hydrochloric acid, 2 percent	E	E	E	E	G	G
Nitric acid, 2 percent	E	E	E	E	G	G
Phosphoric acid, 2 percent	E	E	E	E	E	E
Sulphuric acid, 2 percent	E	E	E	E	G	G
Sodium Hydroxide, 2 percent	E	E	G	E	E	O
Butyl alcohol	E	E	E	E	E	E
Kerosene	E	E	E	E	E-x	E-x
Sodium chloride, 2 percent	E	E	E	E	E	E
Linseed oil	E	E	E	E	E	E
Oil (SAE 30)	E	E	E	E	E	E
Petroleum grease	E	E	E	E	E	E

E—Excellent; G—Good; O—Failure;
E-x—Panel attacked at edge, but film intact.

the combination of heat and corrosion resistance that is to be found in the higher silicone content products. Brown silicone enamels selling in the $7.00-$13.00 per gallon range may contain 20-40 percent of modifying resin since the discoloration on heating will not noticeably change the color. White silicone enamels, on the contrary, must be made from substantially 100 percent silicone binder in order to retain acceptable whiteness after prolonged exposures in the 400-550 F. range. White silicone enamels of this type sell for $20.00-$30.00 per gallon.

While this may seem like a very high price for a gallon of paint, the reasons are evident from cost calculations, Table IV. It is obvious that this five or six-fold higher materials cost plus higher processing, packaging, research, and testing costs must be justifiable from an economical standpoint, otherwise no silicone finishes would be purchased. The main justifications for using colored silicone finishes are:

1. They are the only organic surface coatings available for certain jobs (heat resistance, durability, electrical properties).

2. Simplified design made possible by the heat, resistance of the silicone finish will more than save the extra cost involved in the use of this finish. (For example, the re-design of one oil-burning space-heater finished in silicone enamel involved both a reduction in amount of insulation used and in the number of baffles required to keep the outer shell cool. These design savings were appreciably greater than the in-

TABLE III

HOW SILICONES COMPARE WITH HEAT RESISTANT ALKYD-MELAMINE BASE ENAMELS

	WHITE ENAMELS		BROWN ENAMELS	
	Silicone	Alkyd-Melamine	Silicone	Alkyd-Melamine
60 deg gloss reading (after initial bake)	70	70	75	80
60 deg gloss reading (after heating for 24 hr. at 550 F)	75	8 (tends to flake off)	75	8
Flexibility test (180 deg bend over ½ in mandrel after initial bake)	OK	Slight cracking	OK	OK
Flexibility test (180 deg bend over ½ in mandrel after 24 hr. at 550 F)	OK	Bad Failure	OK	Moderate Failure
Abrasion resistance (Taber CS 10 Wheel Wear Factor—MG/100 cycles)	113	81	83	66
Hardness (Sward rocker)	19	29	18	19
Adhesion to steel	Excellent	Good	Excellent	Excellent
Oil resistance, 48 hr.	Excellent	Excellent	Excellent	Excellent
Color retention after 24 hr. at 550F)	Excellent	Poor (Brown)	Excellent	Poor (Gray)

creased cost of the finish used.

The heating stove industry leads in the adoption of this new group of products. A non-silicone heat-resistant brown enamel and a modified silicone brown, as they emerge from the initial production bake, are both hard and flexible, tough, adherent and have good smoothness and luster. After 24 hr. at 500 F, the silicone type is practically unchanged; its gloss, color retention and film properties remain good. It will withstand a 180 bend over a ½ in. mandrel after the heat test without showing visible failure.

Conversely, the conventional type loses its gloss and color, and its film integrity is poor. Bending the coated panel bearing this finish results in bad flaking. By raising the temperature even higher—to 575 F for 24 hr—the comparison becomes even more dramatic. At this higher temperature even the silicone material undergoes a slight color change, but the conventional product breaks down completely.

Another "stove" application is on Army Quartermaster vehicles, Fig 4 which are equipped with heaters that develop a temperature far beyond that attained in civilian trucks or automobiles. Finish specifications call for a protective olive drab coating which, among other things, must have a salt spray resistance of 300 hr. after being subjected to a heat test of 4 hr at 500 F. The best non-silicone materials (other than ceramics) failed badly after the 500 F heat test. Ceramic materials held some promise for this job and were actually given a production trial. Difficulties in handling, inability to touch up numerous rejects, and brittleness of the final products, were some of the shortcomings which made the ceramic type impractical.

Several manufacturers in the automotive field are considering the use of silicones to "dress up" their product. Already, certain heat-exposed portions of one of the high quality prestige cars are being finished with a high heat resisting black silicone product. Tests under way at the moment point optimistically to the success of colors designed to add striking eye appeal to such parts as manifolds and exhaust parts which normally become unsightly through oxidation caused by heat. These new colors will harmonize with body finishes.

Silicone Colors for Appliances

During the past year there has been much speculation in the appliance field about the utility of silicone finishes. Shortages of plating metals led to a search by some companies for replacements that would "stand up" and still retain the attractiveness of chrome plate. Many novel silicone finishes were worked out—mostly polychromatic shades of brown and tan, sometimes with contrasting colors. Some designers investigated transparent copper and gold effects that had to be applied over polished metal to give satisfactory results. Al-

though none of these emergency finishes has actually been put into production, many have been sufficiently evaluated to indicate another potential spot for silicone coatings. Toasters, sun lamps, sterilizers, roasters, and bakers, irons, heating fans, reflectors, and many other products are logical applications. A silicone finish produces a pleasing effect over such metals as polished steel and aluminum. Exact color shades may be varied by regulating the film thickness and the color intensity in the coating.

How well these coatings withstand elevated temperatures is illustrated in Fig. 3. The panel (top left) was baked 15 minutes at 450 F. The next panel is the same material subjected to an additional bake of 48 hr at 500 F. The change in color and gloss is barely perceptible. By comparison, the non-silicone gold finish (bottom) turns color when subjected to 500 F, and is almost completely volatilized at 575F.

Finishes for Glass

Clear and pigmented heat resistant finishes for glass are sometimes required in colors. Silicones fit admirably in this field. Light bulbs that must be colored in different shades for various purposes have been successfully finished in silicone colors. Bulbs that cannot withstand porcelain baking temperatures or that can more readily be production adapted to the use of silicone finishes are typical applications. Radio and TV tubes which require heat resistant identification markings are among other uses. Some of these coatings have been applied by silk screening processes with the same ease as conventional lacquer or enamel coatings.

Use on High Speed Airplanes

Intricate new aircraft assemblies subjected to ultra-high temperatures rely on silicone colors not only to protect valuable metal components but also to identify readily the location of vital members.

Whereas ordinary organic finishes crack, or flake off and are destroyed by the extremes of high and low temperatures encountered, silicone resin-based coatings have been found to hold up satisfactorily. Aluminum, white, red, blue, black and yellow are among the colors used.

An interesting sidelight to these aircraft applications is the development of an aerodynamic smoothing compound based on silicone resin made to withstand high and low temperatures. This compound was designed to be knifed or sprayed, sanded and recoated with the silicone color enamels.

Color Coding

In several applications, silicone finishes have been applied not only for protection but also as a means of identification. For example, resistors must be protected from moisture and other

Fig. 5—Cleaning operation on Stewart Warner wall heater panel, and finished unit, which is available in ivory or beige colors. See last page for other Stewart Warner application.

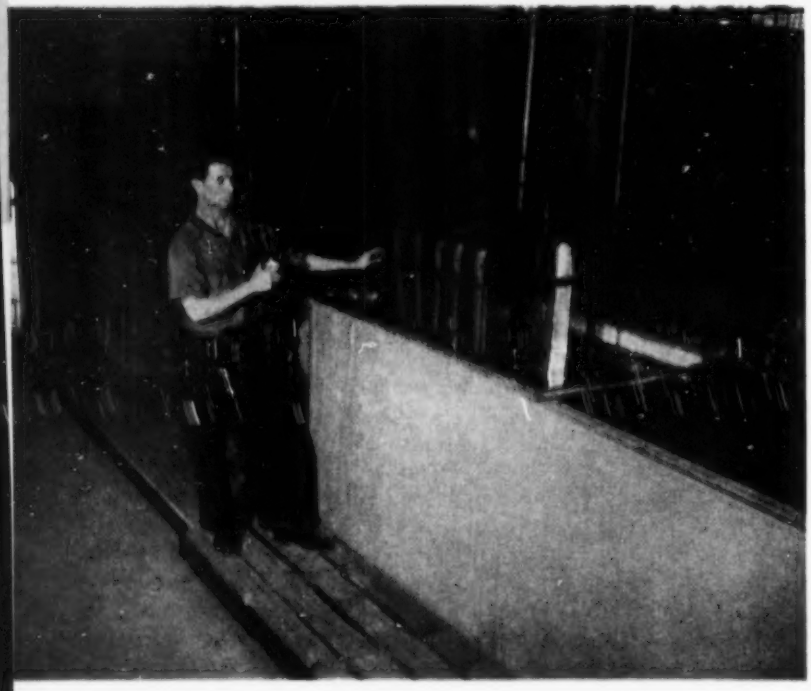
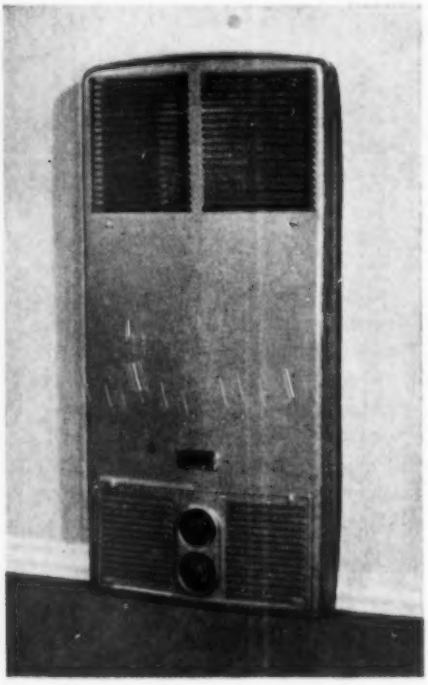


Fig. 6—(Right) Unit heater produced by the Florence Stove Company of Gardner, Mass., and finished with a silicone coating. Other colors are also available.



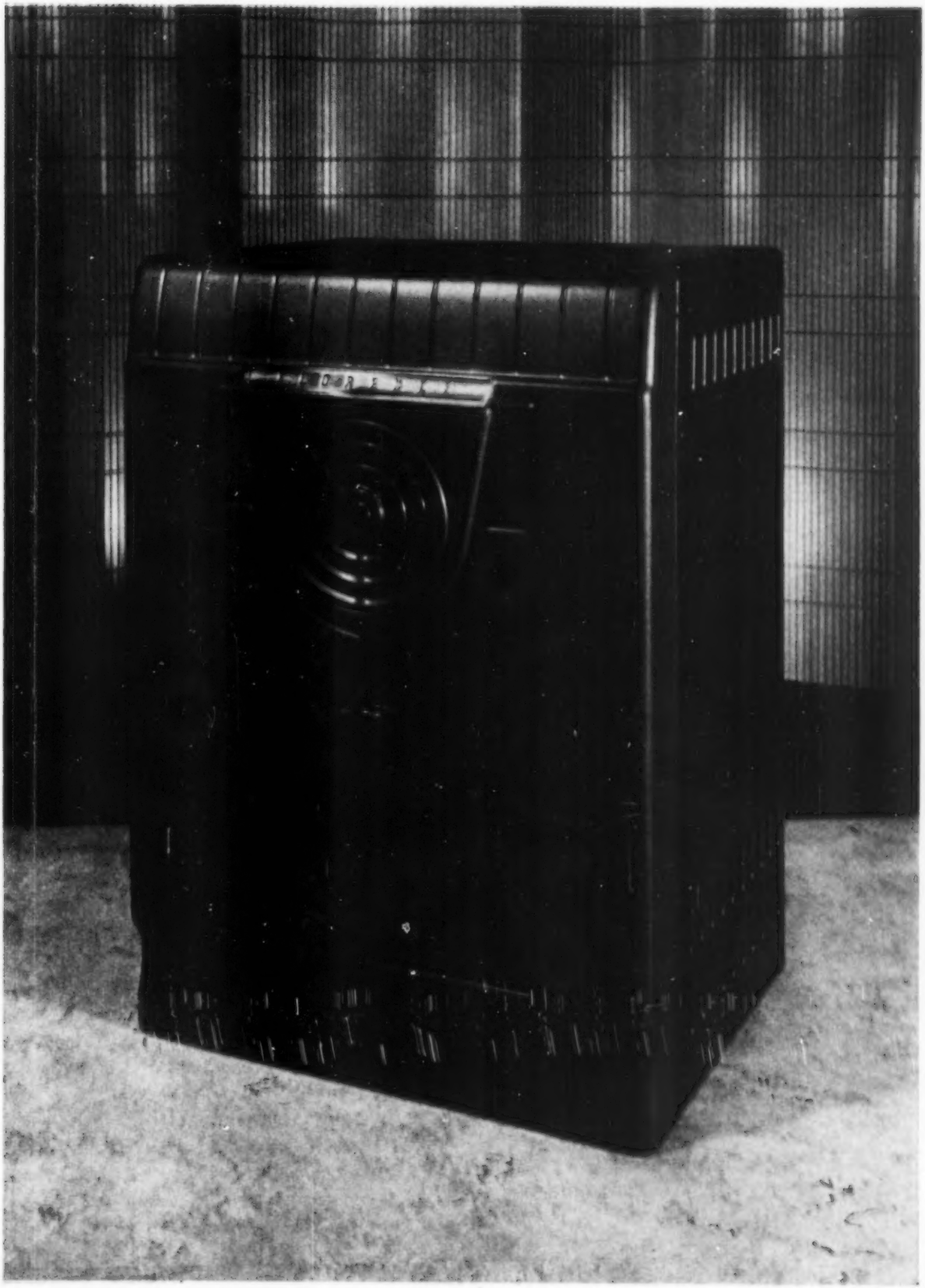


TABLE IV

COST OF INGREDIENTS FOR ALKYD-MELAMINE AND SILICONE BASE WHITE ENAMELS

Cost of Ingredients Ingredient	Cost/lb.	Alkyd-Melamine Lb.	Gal.	Cost	Silicone White Enamel Lb.	Gal.	Cost
Titanium dioxide	$0.23	250	7.15	$57.50	250	7.15	$57.50
50% alkyd resin	0.26	500	60.00	130.00	....	.....	.....
50% silicone resin	1.80	....	.....	.....	686	82.50	1233.00
50% Melamine formaldehyde resin	0.40	186	22.50	74.30	....	.....	.....
Solvent	0.08	73	10.35	5.84	70	10.00	5.60
Catalyst	0.24	....	.....	.....	3	0.35	0.72
	....	1,009	100.00	267.64	1,009	100.00	1,296.82
Total raw material Cost			$2.68/gal			$12.97/gal	

Fig. 7—Another Stewart Warner heater application (top) and Autocar truck having an aluminum pigmented silicone finish on the exhaust manifold and piping.

corrosive agents, but colored silicone resistor coatings are also used to facilitate the identification of resistance rating. Still another use for colored silicone paints is in marking inks. These inks can be applied over light colored silicone resistor coatings to provide excellent contrast, with a resultant ease in reading. The silicone paints used for these applications will withstand virtually all the operating temperatures encountered. Superheated steam lines which must be identified as to source and direction also have been successfully coded. The housings of different types of electric motors are now often painted with various shades (yellow, red, green, etc.) of silicone enamel, to distinguish one type from another.

Specialty Coatings

Although present silicone coatings do not lend themselves to the crackle and wrinkle types of specialty finishes, they may be formulated to give a "veiling" effect. This effect is used to cover up and hide imperfect metal surfaces and to give a characteristic appearance to a manufacturer's product. Other specialty finishes for which the silicone resins have special merit include coatings for wire wound resistors (good electrical properties, excellent resistance to humidity and salt spray, moderate cost) and fungicidal coatings for tropical equipment heating up on use to over 150 Fahrenheit.

Solenoid Operated Shutoff Valves

For Aircraft Hydraulic Circuits

KENDALL JONES
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Circuit requirements and service considerations that influence the selection and application of solenoid shutoff valves in aircraft hydraulic systems. Variables that govern solenoid design.

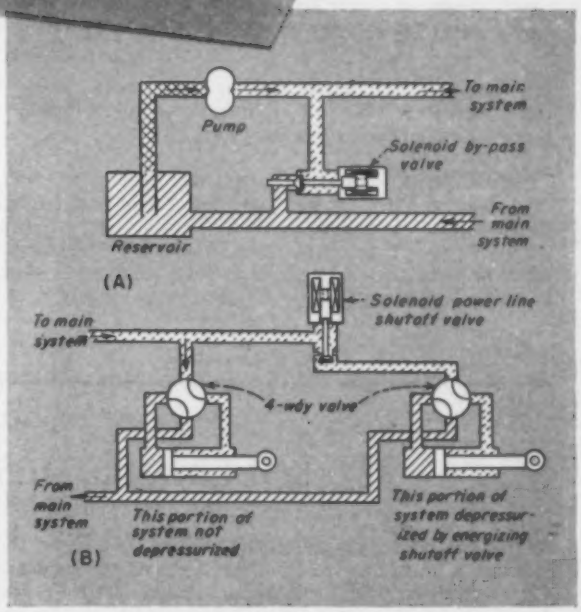


Fig. 1—(A) By-pass function with normally closed valve. When open, this valve short circuits the system by returning the pump flow directly to the reservoir. (B) Power line function with normally open valve. When closed, this valve depressurizes a portion of the system while maintaining pressure in another.

SIMULTANEOUSLY with the intensive activity in aircraft hydraulic systems, many types of shutoff valves have been developed to meet operational requirements. Little standardization has been achieved and new designs are in constant demand. Since these systems are automatic in operation, the qualities of dependability, durability, and efficiency are of especial importance.

Solenoid operated control valves can be inserted where needed without complicating the tubing layout. The distance between the valve and the point of control can be conveniently spanned by light flexible wiring. The control unit can be a switch in the cockpit or a series of sequencing switches on mechanisms in the airframe.

Coordination between the accessory designer and the systems engineer is essential in the selection of valves for any particular system. Valves of one design may be prone to fail under the influence of ambient conditions such as heat or icing, and those of another design when internal conditions exist such as reversals of pressure, surges of flow, or contaminants in the hydraulic fluid.

To provide adequate safety of the aircraft in event of electrical failure, the valves should return to a position that permits accomplishment of an essential service by some auxiliary means. Shutoff valves, therefore, are "normally closed" in some applications and "normally open" in others.

Weight of the components in the aircraft hydraulic power system is second in importance only to dependability. One fundamental attack on weight is to increase the operating pressure. Today, nearly all systems are operated at least partially at 3000 psi. With increased pressure, the volume of hydraulic fluid required per horsepower is decreased, thus permitting the use of smaller pumps, motors, cylinders, tubing and valves with consequent saving of weight. With solenoid valves some of this advantage is lost, since increased pressure increases the work load on the solenoid, which in turn requires an increase in the size of the solenoid.

The design and application of solenoid shutoff valves are influenced by: Circuit requirements, permissible pressure drop through the valve, speed of operation, response time, amount of internal leakage that can be tolerated when the valve is closed, duty cycle of operation, ambient temperature, and the presence or absence of sand, mud, water or ice in the vicinity of the valve.

The typical requirements for power-system and for auxil-

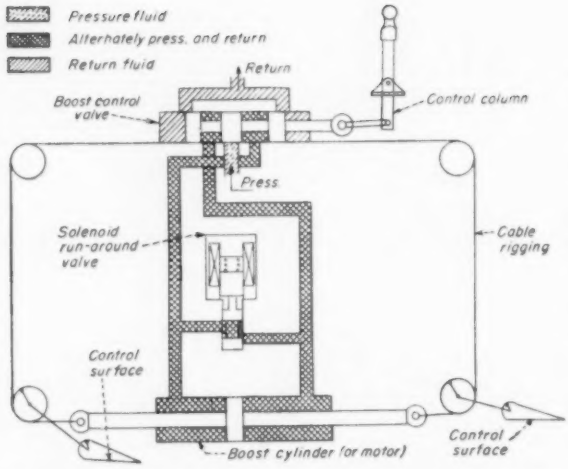


Fig. 2—Run-around valve, shown normally open, for double-ended cylinder or motor. To use power boost, the run-around valve is energized or closed to apply pressure to the cylinder.

iary system shutoff valves can be more easily discussed along with some examples of hydraulic circuitry in which system considerations affect the valve selection.

POWER SYSTEM SHUTOFF VALVES. The by-pass function, in which the valve short circuits the system and returns the flow from the pump directly to the reservoir, is shown in Fig. 1(A). This arrangement depressurizes the system while in flight and thus reduces the loss of hydraulic fluid if a tube is ruptured and also the ensuing fire hazard.

A valve for this service needs pressure and flow capacity in one direction only; its leakage allowable would ordinarily be generous. Only the inlet chamber need be designed for the system pressure. The pressure drop should be low to minimize the power loss during depressurized periods. The valve should be normally closed, so that in the event of electrical failure the system pressure is restored and available when needed.

A power line shutoff valve, Fig. 1(B), is distinguished from the by-pass type by the ability to operate with system pressure in both ports. This function might be required to depressurize a portion of the hydraulic system for safety during flight, while maintaining pressure in another portion that is used continuously during flight.

When the valve is open, system pressure is delivered to the various functions downstream so that a low pressure drop is important. When closed, valve leakage must be as small as possible. A normally open valve would be selected, since the essential hydraulic services would continue when needed in the event of electrical failure. In this instance, only the precautionary function of depressurization would be lost by electrical failure.

An application requiring ability to operate equally well in both directions, known sometimes as run-around service, is shown in Fig. 2. Under normal conditions, the run-around valve remains closed while pressure is applied to the cylinder or motor that is shunted by the valve. The valve is alternately pressurized on each port. While not ordinarily critical on internal leakage, the amount of leakage should be the same when pressurized from either side.

The valve functions as a safety device in the event of either hydraulic or electrical failure. Since a hydraulic cylinder or motor when full of fluid acts as a pump if moved by an external force, the cylinder or motor can be locked hydraulically by failure of its control valve. In such

SOLENOID DESIGN VARIABLES

The key to the design of efficient solenoids is in the selection of flux areas and densities in the magnetic circuit. The basic elements of a solenoid are shown in Fig 4. The flux density generated by a coil depends on its ampere-turns. The amount of flux in any section normal to the direction of flow of the magnetic circuit is the same as that in any other section of the circuit, therefore, the flux density of the circuit varies inversely with the areas of the respective sections.

When magnetic flux passes through an air gap between the movable iron core and the fixed iron stop, the magnetic force acting to move the core with its load varies with the square of the flux density in the air gap, directly as the area of the flux stream normal to the direction of flow, and inversely as the square of the length of the air gap. These relations are only true up to the point where flux density in any portion of the magnetic circuit approaches the saturation value of the magnetic material used. It is necessary, therefore, to select all areas in the magnetic circuit large enough to prevent saturation effects.

Since the volume and weight of copper required increases with the ampere-turns to be generated, the first line of attack on size and weight is reduction of both length of the air gap and of the flux density required. The flux density required can be reduced up to a point of optimum compromise by increasing the size of the core or by reducing the work load. The length of the air gap and the reduction of the work load are problems in valve design.

The ampere-turns generated by a coil at a given voltage depends on only three design variables: (1) Mean diameter of the coil, or average length of turn of the magnet wire; (2) diameter of the magnet wire; and (3) unit resistance of the material of the magnet wire.

The coil diameters are determined after establishing the core diameter necessary to give the desired work capacity; the mean diameter is made as small as possible.

With the mean diameter established, the wire diameter or gage governs the ampere turn-value of the coil. Increasing the wire diameter increases the ampere-turns; this statement may appear odd, since the number of turns possible is less in direct proportion to the increase in diameter of the wire. The resistance per unit length, however, is reduced also in proportion to the increase in area, giving an exponential increase in current and thus a net increase in the product of amperes times turns.

The third variable, unit resistance or resistivity of the material, is important because it varies rapidly with temperature. The coil must be designed to deliver the required ampere-turns at the maximum temperature expected in service, considering both ambient temperature and the temperature rise of the coil from its consumption of power.

The power required by the coil is not directly influenced

an event, the service operated by the cylinder or motor could not be operated by manual means. To permit manual operation of the service affected, the run-around valve is connected across the cylinder or motor to provide a low-loss path for the fluid that is pumped back and forth.

In addition, the run-around valve must be able to open on signal regardless of direction of pressure, and while open permit flow in either direction with low pressure drop.

With a double-ended cylinder having piston rods of the same diameter extending from each end, such as shown in Fig. 2, the amount of fluid expelled from one end equals that sucked in at the other end when cylinder is moved back and forth manually.

When run-around provision is required on a single ended cylinder, the circuit shown in Fig. 3 is used. Since the cross-sectional area of the fluid is not equal on both sides of the piston, merely shunting the ends of the cylinder through a run-around valve does not release the hydraulic lock. To accommodate the ebb and flow of make-up fluid during manual operation, the circuit must be vented.

In the method shown, Fig. 3, the downstream ports of two shutoff valves are connected together and to a fluid return line. Each cylinder connection is teed into the pressure port of one of these valves. When run-around is required, both valves are actuated. From the standpoint of fail-safe requirements, this arrangement is of interest since electrical failure might occur in only one of the valves.

Since each valve is pressurized only at inlet port, with no possibility of downstream pressure, the functional requirements are the same as for by-passing service except that, since flow through the valve is required in both directions, an unidirectional pilot valve could not be used. Normally open valves would usually be selected to assure manual control in event of electrical failure.

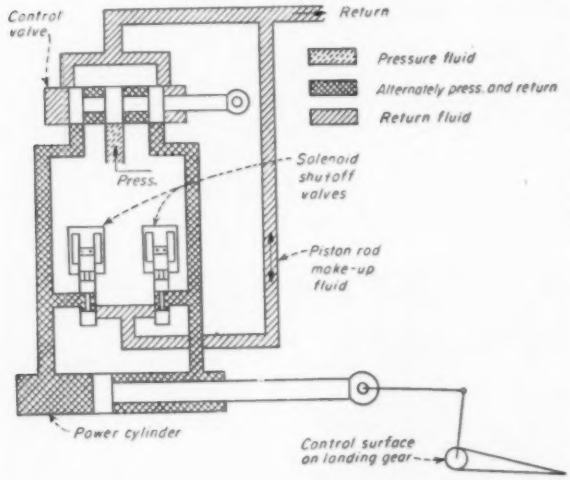


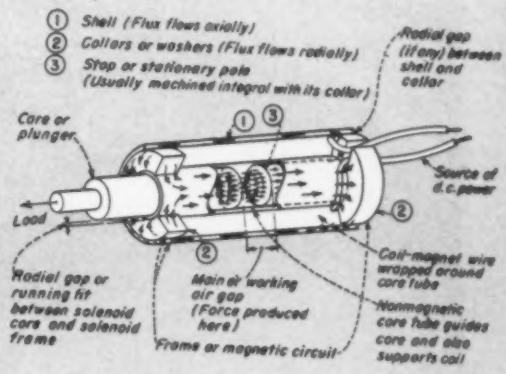
Fig. 3—Run-around provision for single-ended cylinder using two shutoff valves; valves are shown normally open. When run-around is required, both solenoid shutoff valves are actuated.

by the ampere-turn requirements, but must be considered for its effect on temperature rise. The diametral parameters of the coil having been established in meeting the ampere-turn requirements of the magnetic circuit, only the length of the coil remains as a design variable affecting the power input and the temperature rise.

Neglecting temperature effects, suppose a coil *A* is 1 in. long, has 1,000 turns and draws 1 ampere, then 1,000 ampere turns would be produced. Another coil *B* is ½ in. long, but has the same diameters and is wound with the same size wire as coil *A*. Coil *B* would then have 500 turns but would draw 2 amperes and also give 1,000 ampere-turns. Another coil *C* if wound with one turn of the same size wire on the mean diameter of coil *A* would draw 1,000 amperes and also produce 1,000 ampere-turns. If these coils operate at 24 volts, coil *A* would require 24 watts, coil *B* would require 48 watts, and coil *C* would require 24 kilowatts.

The power input to the coils appears as heat that causes the temperatures of the coil and the solenoid to rise. The temperature rise that can be tolerated depends on the ability of the insulating materials (and the valve seals, if they adjoin the solenoid) to withstand heat. The length and weight of a solenoid, therefore, are governed by permissible temperature rise.

The force and stroke required to operate the valve determine the size and capacity of the solenoid. A future article will discuss the design problems encountered in reducing the size and weight of the overall assembly through an integration of the solenoid and valve.


1 Shell (Flux flows axially)
2 Collars or washers (Flux flows radially)
3 Stop or stationary pole (Usually machined integral with its collar)
Radial gap (if any) between shell and collar
Core or plunger
Source of d.c. power
Load
Coil-magnet wire wrapped around core tube
Radial gap or running fit between solenoid core and solenoid frame
Main or working air gap (Force produced here)
Nonmagnetic core tube guides core and also supports coil
Frame or magnetic circuit

Arrows indicate direction of flux for one polarity of source of d-c power. Reversing the polarity reverses the direction of flux but does not affect solenoid operation.

For flux passing through iron path, the ampere-turns required depend on the degree of saturation of the iron. 20 to 30 ampere-turns per inch of length give about 50 percent of saturation flux density for the material. Full saturation may require 200 to 500 or more ampere-turns per inch of length. Flux in excess of saturation requires same excitation that would be required if the paths were nonmagnetic.

Where

NI = ampere-turns
B = flux density, kilomaxwells psi
L = length of nonmagnetic path, in.

for flux passing through air or nonmagnetic paths, the basic formula relating flux density and ampere-turns is

$$NI = 0.313\ BL$$

All working flux passing through the radial gap (if any) between the shell and collars and all working flux passing through the radial gap between the core and collar requires an ampere-turn excitation as determined by the basic formula. This loss in ampere-turns is minimized by making the length of the gap small or by making the flux density in this gap small by using a large area.

Coil design considerations: (1) Number of turns is governed by diameter of wire and the area normal to the turns; (2) Resistance, and therefore amperes per volt, is governed by wire diameter and volume of winding space; (3) Insulation of winding from frame can be achieved by winding the wire on a fibre or plastic bobbin, or by applying insulation directly to frame.

Table I—Mechanical Properties of Leaded Bearing Bronzes

Nominal Composition	85-5-5-5		85-5-9-1		83-7-7-3		84-8-8-0		80-10-10-0		75-5-20-0	
SAE No.	40		66		660		None		64		None	
CASTING METHOD	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast
Tensile strength, psi	45,000	36,400	39,000	32,000	44,000	40,400	43,000		39,000	35,000	30,000	26,900
Yield strength, psi	21,400	16,900	18,000	16,000	27,000	19,500	24,000		25,000	17,000	18,000	15,800
Elongation, percent in 2 in.	28	35	34	18	16	39	22		10	15	13	17
Rockwell hardness, *B* scale	43		32		46		46		48		16	
Brinell hardness, 500 kg. load	72	49	65	62	72	65	74		74	65	37	45
Impact strength, ft-lb	20.7	12.0	13.0		12.5	9.3	13.0		6.0	4.5	6.2	5.5
Endurance limit, psi	16,000	8,500			20,000	12,000			22,500	16,000	16,000	12,500

NOTE 1: Nominal composition given in following order: Cu-Sn-Pb-Zn-Ni.
NOTE 2: Endurance limits at 20×10^6 cycles. NOTE 3: Impact tests in accordance with ASTM E23-41T Type Z.

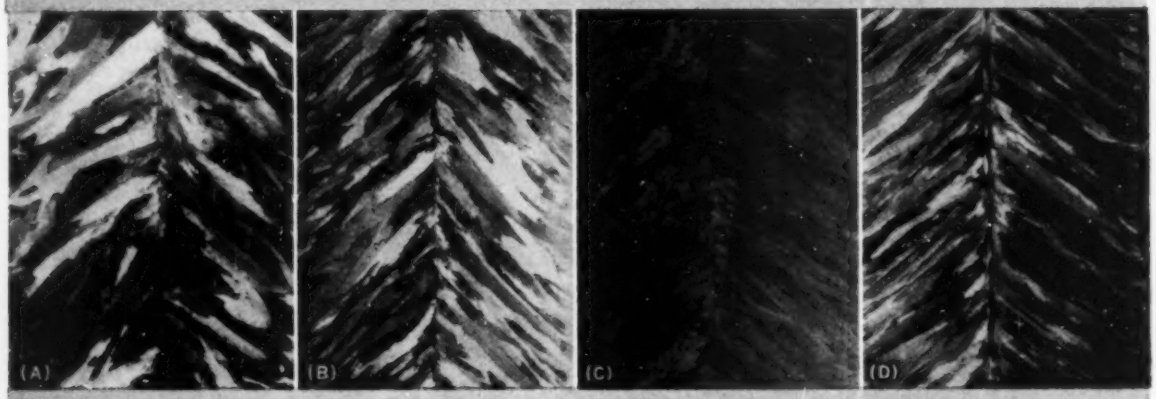


Fig. 1—Macrophotographs of continuous cast copper-tin-lead-zinc alloys show the relatively coarse chevron-like grain formation, reflecting the directional extraction of heat with a minimum of turbulence; (A) 88-10-0-2, 1¼ in. dia. rod; (B) 85-5-5-5, 1¼ in. dia. rod; (C) 83-7-7-3, 1¼ in. dia. rod; (D) 75-5-20-0, 1¼ in. dia. rod.

Modern Continuous Cast

CONTINUOUS CAST COPPER alloy products fall into two general categories—(1) base castings, such as brass and copper billets, rods, bars or slabs, from which are manufactured sheet, strip, rod, wire, tubing and shapes by conventional mill operations; and (2) the more recently developed cast-to-size bronze products such as rods, tubes and shapes, which are being produced by a new process developed by the American Smelting and Refining Company. The latter products find extensive application for manufacture of bearings, bushings, shafts, gears, nuts, studs, fittings, sleeves, valves and miscellaneous structural parts by machining directly from the cast and straightened forms.

Continuous casting of leaded and non-leaded bronzes has several advantages over other casting methods because of the nature of the melting, casting and cooling techniques involved. These advantages are:

(1) Overall economy

(2) Faster production through the conversion of molten metal to solid form in dimensions as close to finish size as practical.

(3) Chemical uniformity because of the reduction of variations normal to small batch melting and casting.

(4) Improved physical quality (metallurgical consistency and freedom from flaws) through the technique of bottom pouring and freezing.

Basic Structure and Properties

Continuous cast bronzes have excellent tensile strength, hardness, and impact and fatigue strength. The

Table II—Mechanical Properties of Non-Leaded and Low-Lead Bronzes

Nominal Composition	89-11-0-0		88-10-0-2		88-8-0-4		88-10-2-0		84-10-2.5-0-3.5 Ni		83-6-1.5-4.5	
SAE No.	65		62		620		63		None		622	
CASTING METHOD	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast	Continuous Cast	Sand Cast
Tensile strength, psi.	55,000		53,000	50,000	51,000	48,000	49,000		59,000		45,000	3[illegible],000
Yield strength, psi.	26,500		25,000	20,000	22,000	18,000	23,000		34,000		23,000	18,000
Elongation, percent in 2 in.	26		30	25	52	45	29		15		40	35
Rockwell hardness, *B* scale	59		57		51		57		65		50	
Brinell hardness, 500 kg. load	86		86	76	74	72	80		89		72	70
Impact strength, ft-lb	35.0		25.5	8.7	22.0		11.0		14.0		28	
Endurance limit, psi.			24,500	13,000			21,800		24,[illegible]00			

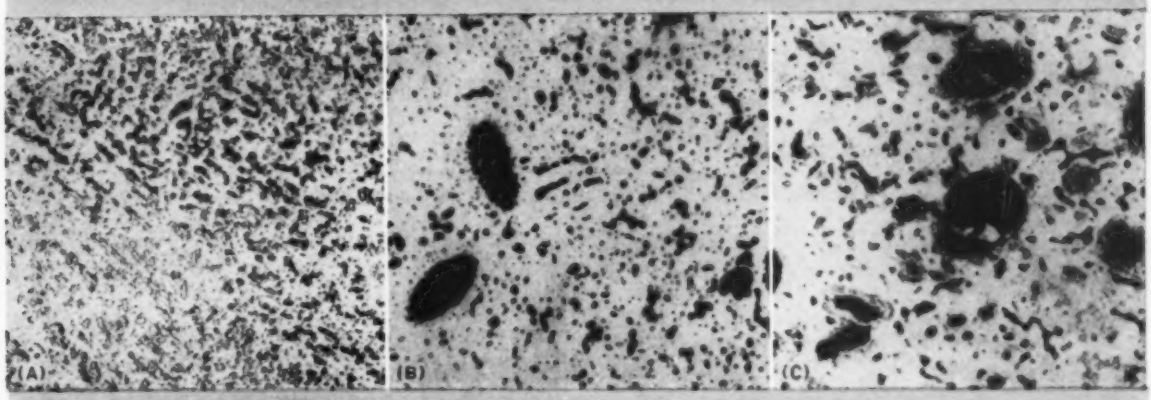


Fig. 2—Comparison in microstructures between continuous cast, sand cast and permanent mold high leaded bronzes (75 Cu-5Sn-20Pb) show the finer grain size and more even dispersion of lead in the continuous cast product. Macrophotographs show: (A) continuous cast; (B) conventional permanent mold; (C) sand cast.

Copper Alloys

J. L. KIMBERLY
Continuous Cast Products
American Smelting and Refining Company

mechanical properties of leaded, low-leaded and non-leaded bronzes cast by both sand and continuous casting are listed in Tables I and II. The higher values obtained in continuous cast metal are attributed to its uniformity and fine-grained microstructure.

Metallographically continuous cast bronzes are characterized by a relatively coarse chevron-type macrostructure and an extremely fine microstructure. The basic grain formation, Fig. 1, clearly reflects the directional extraction of heat with a minimum of turbulence; Fig. 2 shows the comparison in microstructures between continuous cast, sand cast and permanent mold high leaded bronze. The continuous cast metal is seen to have a fine and uniform grain size and an even dispersion of secondary constituents because of rapid heat extraction.

The Casting Process

At least seven commercial continuous casting processes have come into use during the past fifteen years. These are the D. C., Dow Chemical, Hunter Douglas and Properzi processes for aluminum, magnesium and their alloys; the Wellblund-Benard, Junghans-Rossi and the ASARCO processes for copper and its alloys. In all cases, except in the ASARCO process, only base castings have been produced.

The ASARCO continuous casting process Fig. 3 operates in the following stages:

(1) Batches are melted for periodic replenishment of the casting reservoir.

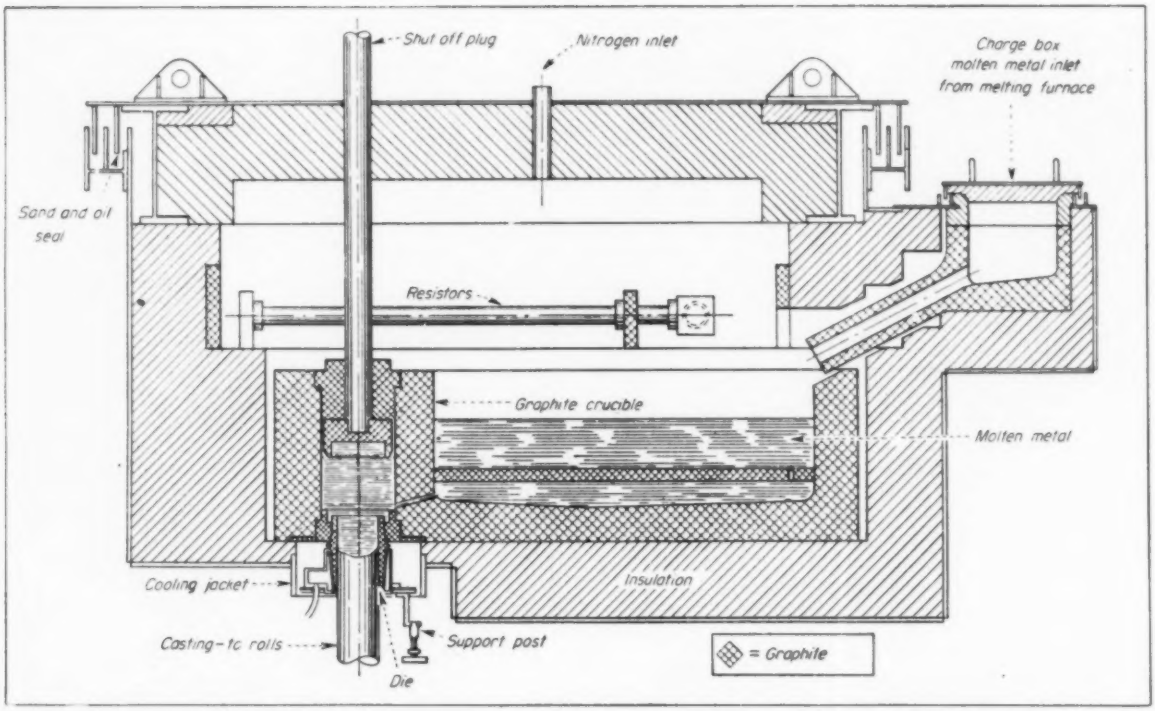


Fig. 3—Cross-sectional view of a continuous casting furnace. Continuous cast rod is drawn through the graphite die at lower left.

(2) The molten metal is introduced into a rectangular graphite casting crucible, where it is maintained in a nitrogen atmosphere at proper temperature by controlled resistance heat, and deoxidized by contact with the carbon system. The desirable metal-to-carbon contact is insured by baffling, which also prevents turbulence at the die end.

(3) In an expendable graphite die, cooling and solidification are accomplished by the rapid extraction of heat through the die wall into a carefully fitted water jacket of high heat extraction capacity. Casting flaws are prevented because: (a) The bath acts as a permanent large riser and prevents shrinkage, (b) any dirt or dross floats on top of the bath and cannot reach the solidifying section, and (c) as freezing occurs, any gases evolved have an ideal escape route from a shallow freezing zone.

(4) Casting speed is controlled by rolls fitted to the product and mounted on a variable speed drive about five feet below the die.

(5) Lengths are cut as ordered on the next lower level by a traveling cutoff clamped to the casting.

(6) After lengths are severed, samples are analyzed and tested for compliance with specifications.

(7) Products intended for machining "as cast" are straightened and are then ready to ship.

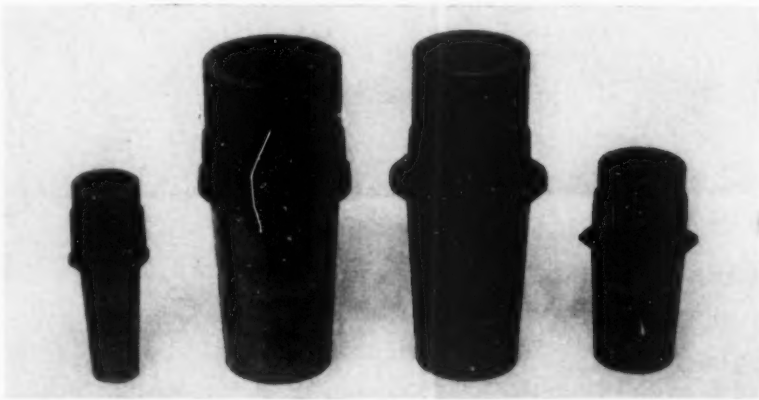


Fig. 4—Some typical graphite dies. The two at the left are rod dies; second from right is a tube die showing metal entry ports and at far right a multiple-hole rod die.

The use of high density graphite for dies Fig. 4 has proved very successful. Since the graphite is readily machined to close tolerances, an excellent conductor of heat, self-lubricating, capable of taking a high polish, resistant to thermal shock, and reasonably economical, it has contributed substantially to the broad flexibility of the overall operation. Sizes can be produced as required to satisfy customers' specific needs, and small quantity orders are practical.

The simplest die is that for single rod production. Solidification takes place in a central portion of the die, and it is frequently necessary to use compound tapers both above and below the freezing zone: "Above" to compensate for the expansion of the "hot top" portion of the die, and "below" to follow the shrinkage of the solid product.

For the production of tubing, rod dies Fig. 5 are suitably equipped with accurately placed and rigid tapered mandrels. Molten metal flows through transfer holes into an annular space

and solidification is complete before the product clears the bottom of the mandrel.

Die wear is evidenced by a gradual roughening of the outer surface of the product. Such roughening is shallow, and after the straightening procedure (which incorporates a moderate overall burnish) has no significant influence on product dimension.

Small rods are produced from multiple hole dies (Fig. 4), and shapes from dies cut on special machine tools. Fig. 6 shows the variety of shapes that can be obtained.

Dimensional Control

Outside dimensional control is relatively simple. Reference to the tolerances in Table III will show basic equivalence with dimensional limits for refractory brass mill products. Variations to be considered in production have resulted from shrinkage factors, and the tendency of alloys high in tin and lead to sweat.

Inside diameter control is somewhat less exact since it is necessary to cast around a tapered mandrel, and it is not practical to control the freezing level exactly.

Concentricity of tubular products is dependent primarily on accuracy in the machining and assembly of dies, and is superior to that attained by any other method for producing tubes in mill lengths.

Inside surfaces, being protected during cooking by a stationary column of hot gas, are excellent—being marred only by superficial oxidation and by sweats in the case of high lead-tin alloy compositions.

Fields of Application

There are three basic fields into which continuous cast products have been directed—to brass mills as alternates for other type castings, to consumers for maintenance and repair and to manufacturers of original equipment.

The soundness, cleanliness and uniformity of continuous cast bronzes make them attractive to brass mills as base billets. Higher quality end products are attainable and workability is superior to other castings. Refractory phosphor bronzes are especially adaptable to this process and high quality stock is obtained.

For maintenance and repair purposes and for small to moderate production runs, continuous cast bronzes have an additional advantage of being available in any length desired, instead of only the conventional 12 to 13 in. stock length. This can net considerable savings of material. For instance, if material is required for eight 5 in. long bearings, four 13 in. bars or 52 in. of standard stock would be needed; 41 in. of continuous cast bronze could be bought to fill the order. This would net a savings in length alone of 11 in. or 21 percent.

The use of continuous cast bronzes for manufacture of screw machine products is predicted on their good machinability, uniformity of structure, good mechanical properties and the availability of custom sizes and alloys. A tried example of their serviceability has been as gear train pinions in water meters. After seven years experience and service, no problems in soundness, mechanical properties or machinability have developed.

It is expected that further development in the production of cast-to-size bronze parts will result in an expansion in scope of the continuous casting process to other shapes, sizes and some additional alloys.

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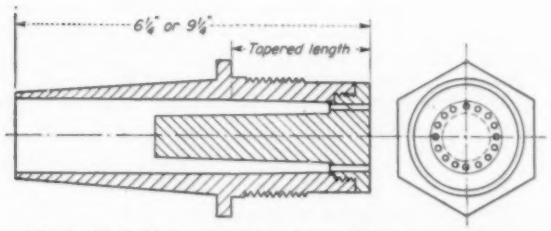


Fig. 5—Tube die cross-section shows the upward taper on the die wall and the downward taper on the mandrel.

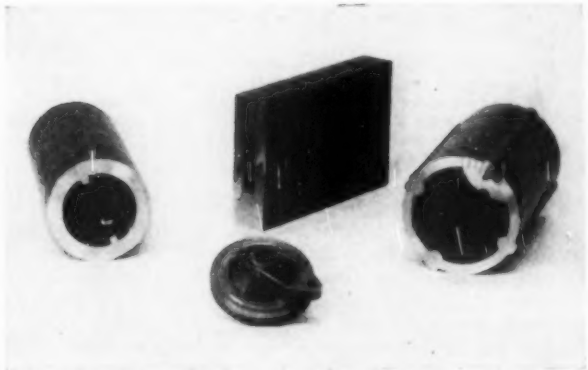


Fig. 6—Some of the shapes now available in continuous cast copper alloys. The part in the foreground is a zinc die casting within a continuous cast bronze shape. The gear teeth were machined.

Table III—Alloys, Sizes and Tolerances

Available Alloys

Commercially available within the following alloy limitations:
Sn — 12 percent max
Pb — 22 percent max
Zn — 13 percent max
Ni — 3 1/2 percent max
Cu — Balance

Size Range

Rods: 7/16 in. min to 5 1/8 in. max
Tubes: O.D.: 1 in. min to 5 1/8 in. max
I.D.: 15/32 in. min
Walls: O.D.: to 2 1/8 in. — 3/16 in. min
Over 2 1/8 in. to 3 1/2 in. — 1/4 in. min
Over 3 1/2 in. — 10 percent of O.D. min

Shapes: Must be basically symmetrical; must be completely encompassed by 5 1/8 in. circle

Lengths

All 1 in. — 12 ft standard
5 to 12 ft on request
Over 12 to 20 ft and under 5 ft on special arrangement.

Stock bronze: SAE-660 (83Cu-7Sn-7Pb-3Zn)
105 in.
Other on special arrangement.

Tolerances

O.D.: Rod and tube, ±0.004 to ±0.006 in.
I.D.: Will clean with 1/64 in. cut
Concentricity: 1 1/2 percent of wall thickness
Straightness: 1/4 in. max arc depth in 5 ft length

Recommended Clean-Up Allowances

In a majority of instances, plus 1/32 in. on the outside and minus 1/32 in. on the inside diameters have proven adequate. For machining of long and/or large diameter parts, 1/16 in. on outside casting diameters is sometimes preferable.

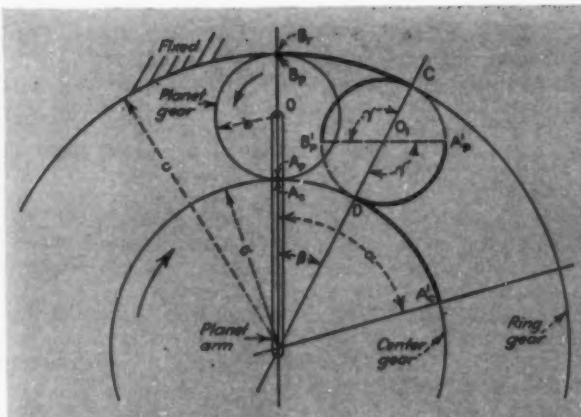


Fig. 1—Simple planetary train with fixed ring gear.

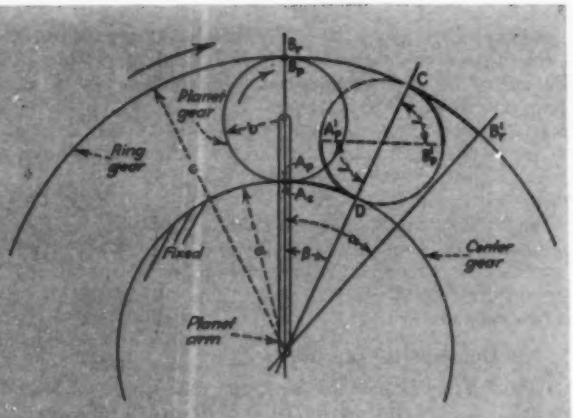


Fig. 2—Simple planetary train with fixed center gear.

A Simple Method of Ratios in Planetary Gear

SIGMUND RAPPAPORT
Ford Instrument Company*

THE COMMONLY USED METHOD of finding the ratio of input to output of a planetary gear train usually calls for considerable faith on the part of the analyst. A data table is developed by subjecting the train to a predetermined series of lockings, unlockings and rotations; then the velocity ratio is found in a specified column and row of the table. Little, if any qualitative understanding of the system is gained in the process.

In the method described below, called the "Method of Equal Arcs," the ratio is derived mathematically and the motion of any element in the train can be followed with respect to the other elements. Thus, the modifications required to produce a given effect is often obvious whereas the previous method may require many blind trial and error substitutions.

Four examples are given to illustrate the application of this new technique to both simple and compound gear trains. In all cases, however, the basic theory is the same. For example, Fig. 1 shows a simple planetary train in which the ring gear is fixed. The center gear and planet arm are movable; either can be driving or driven without affecting the analysis.

For the conditions shown, two points on the planet gear are in mesh; B_p mates with B_r which is on the ring gear, and A_p with A_c which is a point on the center gear.

Rotating the center gear through an arbitrary angle α, causes the planet arm to follow through some angle β, which must be evaluated. As a result of this rotation, the center of the planet gear is at O', and points C and D are the new meshing points with the ring and center gears respectively. A'_p and B_p' are the new locations of the original points of contact.

Since the relative motion between the ring and planet gears is entirely a result of tooth action

$$\text{arc } B_p'C = \text{arc } B_rC \tag{1}$$

Also,

$$\text{arc } A_p'D = \text{arc } DA_c' \tag{2}$$

A_c' is the new location of point A_c when the center gear is rotated as described above.

Furthermore, it can be seen from the geometry that

$$\text{angle } B_p'O_1C = \text{angle } DO_1A_p' = \gamma \tag{3}$$

Thus,

$$\text{arc } B_rC = \text{arc } B_p'C = \text{arc } DA_p' = \text{arc } DA_c' \tag{4}$$

Let

a = pitch circle radius of the center gear
b = pitch circle radius of the planet gear
c = pitch circle radius of the ring gear,
α, β = angular displacement of center gear and planet arm, respectively.

It follows from Eq (4) that

$$\beta c = \gamma b = (\alpha - \beta)\, a \tag{5}$$

Eq (5) is the general equation for the planetary gear train of Fig. 1. As indicated previously, it can be used to solve either of the two types of practical problems that exist: (1) finding the planet arm displacement β when the center gear is the input, its displacement α being given; or (2) finding the center gear displacement α when the planet arm is the input, its displacement β being given.

For type (1),

$$\beta = \alpha \frac{1}{1 + c/a} \tag{6}$$

* Division of the Sperry Corporation

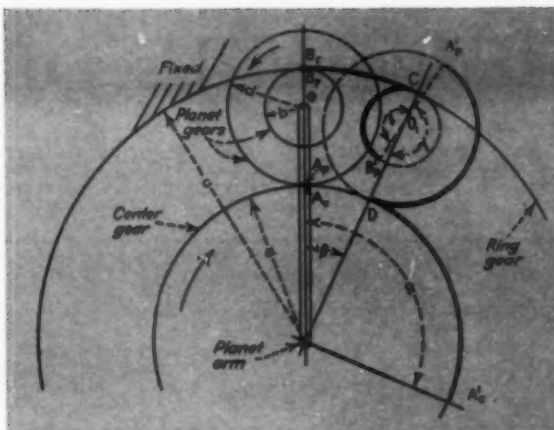


Fig. 3—Compound planetary train with fixed ring gear.

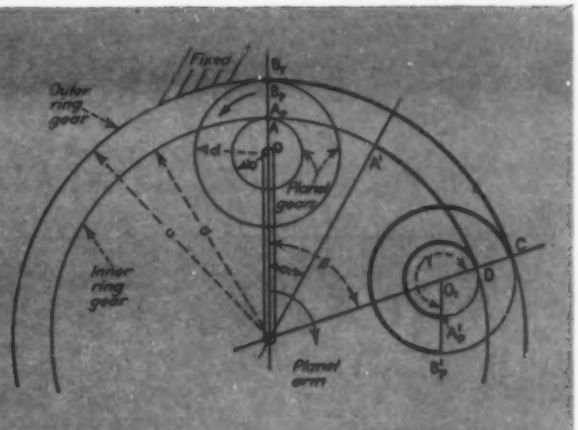


Fig. 4—Compound planetary train with fixed outer ring gear.

Determining Trains

and for (2) $$\alpha = \beta\left(1 + \frac{c}{a}\right) \quad (7)$$

The velocity ratio of input to output will, of course, be either a/β or β/a, depending on which element is the input.

CASE II—FIXED CENTER GEAR

In Fig. 2, the ring gear is rotated through the arbitrary angle a, since the center gear is stationary. This carries point B_r to B_r' and the planet gear arm moves through some angle β. As before

$$\text{arc } A_s D = \text{arc } A_p' D = \text{arc } B_r' C = \text{arc } C B_r' \quad (8)$$

Therefore,

$$\beta a = \gamma b = (\alpha - \beta)\, c \quad (9)$$

For a ring gear input of a, the planet arm output from Eq (9) is

$$\beta = \alpha \frac{1}{1 + a/c} \quad (10)$$

Similarly, for a planet arm input of β

$$\alpha = \beta\,(1 + a/c) \quad (11)$$

Also, solving Eqs (9) and (10) simultaneously

$$\gamma/\alpha = \frac{a}{b}\left(\frac{c}{a + c}\right) \quad (12)$$

This ratio γ/a is equal to the number of revolutions of the planet gear about its own shaft, per revolution of the ring gear.

CASE III—COMPOUND PLANETARY TRAINS

In Fig. 3 the ring gear is fixed; the center gear is rotated through the arbitrary angle a which moves point A_s to the position A_s'; the planet arm follows through angle β. Then, adjacent arcs being equal in length,

$$\text{arc } B_r C = \text{arc } B_p' C \text{ and} \quad (13a)$$
$$\text{arc } A_p' D = \text{arc } D A_s' \quad (13b)$$

Also:

$$\beta c = \gamma b, \text{ and} \quad (14a)$$
$$\gamma d = (\alpha - \beta)\, a \quad (14b)$$

The velocity ratios can be obtained by solving Eqs (14a) and (14b) simultaneously. For example, if the center gear has a given input equal to a, the output of the train is

$$\beta = \alpha\left(\frac{1}{1 + \frac{cd}{ab}}\right) \quad (15)$$

Similarly, if the arm is the input, β being known, then

$$\alpha = \beta\left(1 + \frac{cd}{ab}\right) \quad (16)$$

The velocity ratio a/β or β/a can be developed from either of the latter two equations.

CASE IV

This compound train differs from that of the previous example in that the larger planet now engages the outer ring gear which is fixed, and the center gear is replaced by an inner ring gear with internal teeth to mesh with the small planet.

Rotating the planet arm so that point O moved to O_1 carries point A on the inner ring gear to some point A' while the larger planet rolls up on the outer, fixed ring gear. From Fig. 4,

$$\text{arc } B_r C = \text{arc } B_p' C \text{ and} \quad (17a)$$
$$\text{arc } D A_p' = \text{arc } D A' \quad (17b)$$

Therefore,

$$\beta c = \gamma d \text{ and} \quad (18a)$$
$$\gamma b = (\beta - \alpha)\, a \quad (18b)$$

From Eqs (18) the velocity ratio can be determined as

$$\beta/\alpha = \frac{1}{1 - \frac{bc}{ad}} \quad (19)$$

The four preceding examples illustrate the principles, but should not be interpeted as the only types of problems that can be solved. The "Method of Equal Arcs" can be applied to any epicyclic gear train.

Typical Industrial Uses of

Industrial heating applications can be divided into four categories: contact; immersion; radiant; and air. For these purposes a wide variety of types

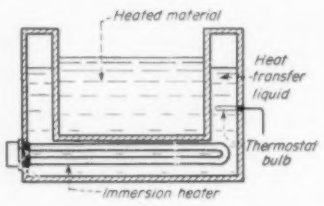


Fig. 1—Indirect immersion heating with tubular type unit located in a transfer medium. Useful for adhesives or other materials that are easily damaged by overheating.

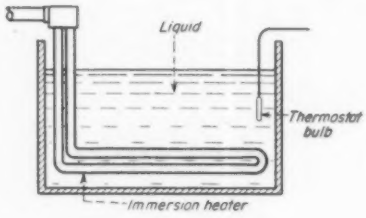


Fig. 2—Direct immersion heating with portable tubular heaters. Can be used for molten salt, oil tempering baths, melting lead, solder, babbitt and stereo-type metal (not zinc).

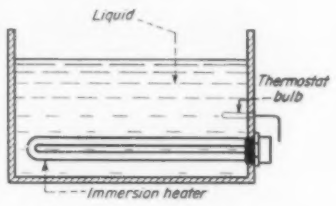


Fig. 3—Direct immersion heating with permanently mounted tubular heater. As with Figs. 1 and 2 when operating temperature is high, heaters with low watt densities must be used.

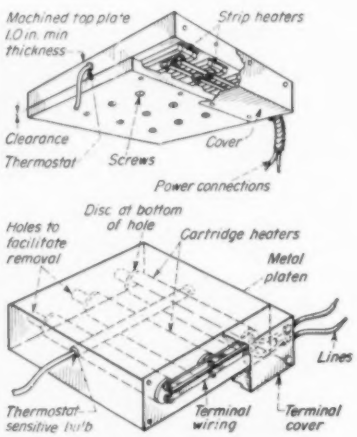


Fig. 6—Moving platens and dies can be heated with strip heaters (above) or with cartridge type units (below).

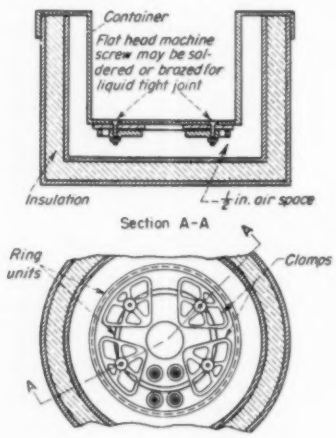


Fig. 7—Ring units are commonly used in thin-walled tanks or containers as shown in the sketch above.

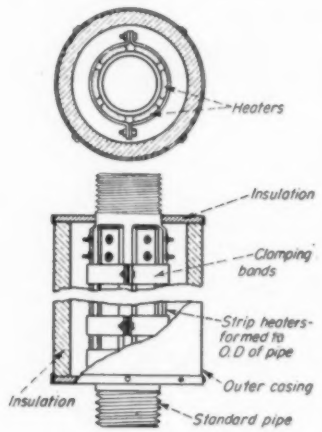


Fig. 8—Strip heaters curved to conform with tank or pipe. Inside radii can be as small as 1 3/16 inch.

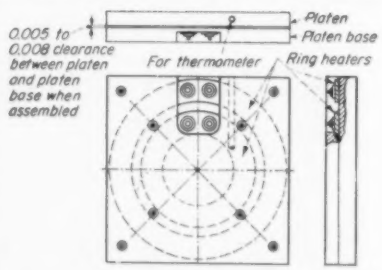


Fig. 11—Ring type heaters can also be used as shown above in parts such as platens, dies and molds. See Fig. 6 also.

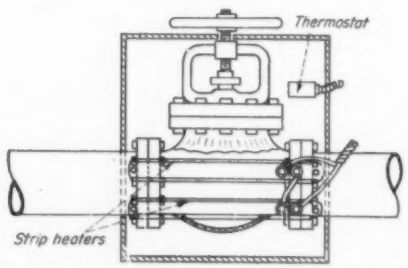


Fig. 12—Strip heaters and thermostat are mounted in sheet metal casing to prevent valves from freezing.

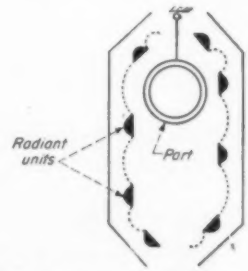


Fig. 13—Radiant heaters for degreasing or paint baking oven. Grease is vaporized for easy removal.

Electric Heating Elements

and sizes of units have been developed. These sketches, which illustrate typical applications of each, were supplied by the Edwin L. Wiegand Company.

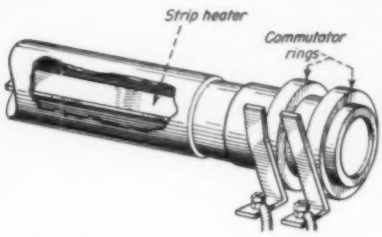


Fig. 4—Strip heater used on machine parts in motion such as revolving rolls. One or more units can be placed within the roll, connected to commutator rings. Brushes wired to power supply contact the commutator rings.

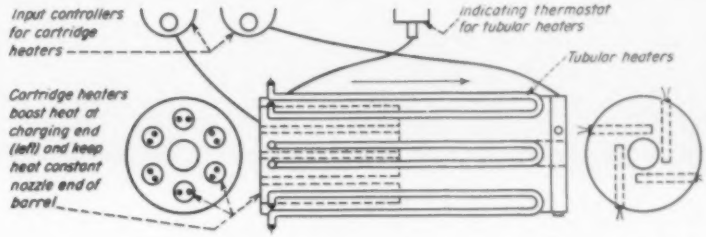

Input controllers for cartridge heaters
Indicating thermostat for tubular heaters
Tubular heaters
Cartridge heaters boost heat at charging end (left) and keep heat constant nozzle end of barrel

Fig. 5—Six thermostatically controlled tubular heaters are used in conjunction with the cartridge units as shown to provide flexibly controlled zones of heat. Each set of cartridge units is separately controlled. Thus, heat is regulated closely and temperatures can be duplicated.

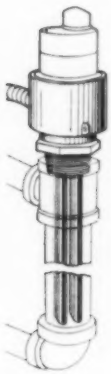


Fig. 9 — Immersion heater screwed into standard tee fitting for heating liquids or steam.

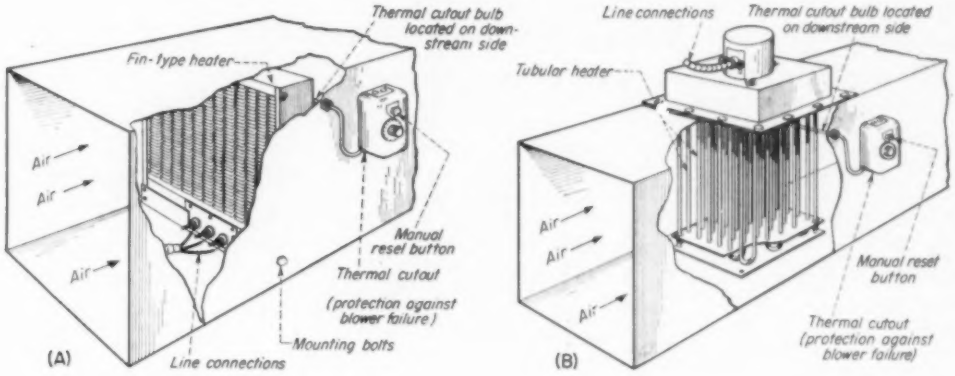


Fig. 10—Two types of heaters for forced air duct installations. Tubular type (*B*) is recommended for higher temperature uses than finned-units in (*A*). Operating temperatures can be over 1,000 F with air velocities greater than about 6 ft per second.

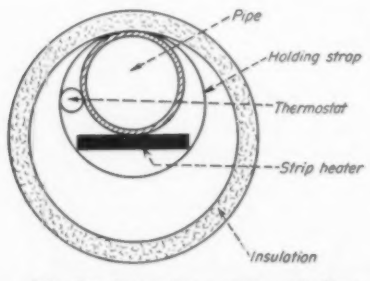


Fig. 14—Long, low wattage strip heaters are strapped to pipe carrying viscous materials like tar or asphalt.

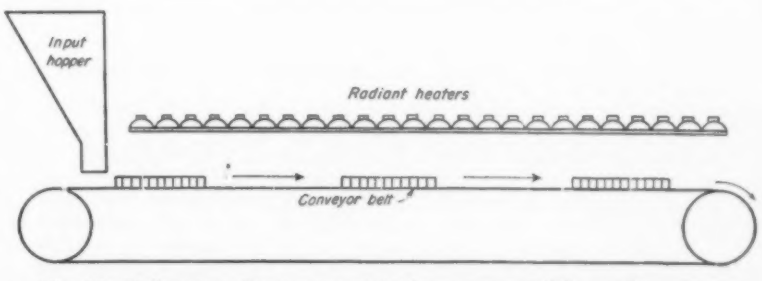


Fig. 15—Radiant type heaters mounted above conveyor belt can be used for drying materials or parts. Wherever possible, radiant units should be staggered and reflectors placed opposite the heaters to distribute the heat evenly.

FEATURES OF THE RELAY AMPLIFIER

1. HIGH GAIN—High ratio of power output controlled by contacts to input power required to trip the relay.

2. FLEXIBILITY—A variety of contact arrangements, closing and opening in a preset sequence with the application of error signal, permits a wide selection of practical and efficient circuit configurations.

3. ISOLATION—Since the contacts are separated from the input coil, the control and power circuits are isolated. Thus output frequency, voltage, and grounding are independent of input conditions. Several separate coils can be wound on the relay so that it will respond to the algebraic summation of two or more signals.

4. EFFICIENCY—The relay has a high efficiency as an amplifier since it connects line and load directly through its contacts, with no intermediate impedance elements.

5. SPEED OF RESPONSE—Commercially available relays will respond to a control signal in less than one millisecond. With proper anticipation circuits, the on-off type of feedback system with a fixed rating driving element is the fastest possible control arrangement.

6. LIFE—Relay life depends on the nature of the load and on the installation of suitable spark suppression circuits. It compares favorably with the life of gas tubes or hard vacuum tubes. However, the relay amplifier has the advan-

Contactor Amplifiers for

The demand for compact and reliable control equipment, and the improvement of nonlinear techniques have resulted in increased use of relay amplifiers in both on-off and proportional control systems.

SIDNEY DAVIS
Research Group
Arma Corporation

ABOUT TEN to fifteen years ago relays were frequently used as amplifiers in automatic control systems, and their simplicity and compactness seemed to assure them a promising future. Then followed the development of the comprehensive mathematical theory of automatic control. Designers found it easier to apply this theory to linear or proportional control systems rather than to the relatively unpredictable on-off type of control. Ironically, although the basic design procedure for the proportional control system is simpler than for the on-off systems, the end product is often more complicated and its performance not as good.

The development of better mathematical techniques for handling nonlinear system equations, and demands for light, reliable miniature equipment by the military, have redirected the designers attention to the relay amplifier. Also, the needs of the new digital computer industry have helped in stimulating the development of faster and more reliable relays which are adaptable to many phases of automatic control applications.

Because relays make possible a high ratio of controlled power to signal power, and have high rapidity of response, unusual flexibility, and long life, they are an almost ideal power amplifier.

Although a relay has the objectionable feature of inherent discontinuity in the output versus input characteristic, this objection can often be minimized or even eliminated by proper circuit and relay design. Also, the large number of relatively inexpensive commercially available types of relays is sufficient to satisfy a wide range of requirements.

Automatic Control Systems

Although the specific equipment employed in automatic control processes can take an unlimited variety of forms, most systems can be represented by the simplified schematic of Fig. 1. The reference variable, R, is compared with a controlled variable, C, and the difference, E, is amplified and applied as a correction to C. Thus C is maintained in a one-to-one correspondence with R. Usually C is at a higher power level than R, an amplifying device included in the block G supplying the necessary energy. The variables can be passed through transducers for conversion to a convenient form for comparison and amplification.

An integral part of all automatic control (or feedback) systems is the element of amplification which operates on the difference between R and C and directs its high energy output toward correcting the deviation. In electrical systems, amplifiers are primarily vacuum tubes, gas tubes, saturable reactors, rotating machines, contactor devices or relays, and recently transistors. This article concerns itself with the contractor amplifier devices.

Fig. 2 – Remote positioning servomechanism based on the use of synchros and a conventional linear power amplifier. The error signal, E, is proportional to the difference between position of the reference (generator shaft) and controlled output shaft.

Fig. 3 – One possible on-off relay amplifier circuit which can be substituted for the power amplifier shown in Fig. 2. Since the error signal is a-c, the direction of the error is indicated by phase. The phase sensitive detector converts the error into d-c, with the error direction being indicated by the signal polarity. The polarized relay is actuated in accordance with the sign and magnitude of the converted error signal.

tage that periodic contact inspection permits anticipation of failure, enabling preventive action to be taken. Costly unexpected shutdowns of equipment can often be avoided in this manner.

7. RATING—Relays are available for driving loads varying from a few watts to several horsepower.

8. COMPACTNESS—The relay is the most compact of all electrical amplifiers. Hundreds of watts can be controlled in a few cubic inches of equipment.

9. COST—Except in specialized cases, relay amplification in electrical feedback systems is the most economical.

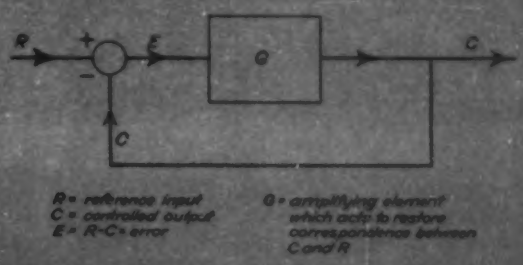


Fig. 1—Block diagram of a typical feedback loop such as used in a large variety of automatic control systems.

Automatic Control

Contactor Amplifiers

Although the variety of physical configurations which may be taken by a contactor amplifier are unlimited, the operating features are governed by a few basic principles.

There are two different modes of operation. In the simpler mode, the relay closes when the error in the feedback process exceeds a certain value. The output, which is controlled by the energized contacts, acts to reduce the error and exerts a constant restoring force with the algebraic sign depending on the error polarity.

In the other operational mode, the relay plus and minus contacts are energized equally in turn by an injected alternating voltage applied to the control coil. The frequency of alternation is chosen sufficiently high so that the inertia of the output member keeps this member from responding to the impulses. When an additional slowly varying direct error voltage is applied to the actuating coil of the relay, the contacts having polarity corresponding to the error polarity will remain closed a larger percentage of the time than will the opposite contacts. The time difference is roughly proportional to the magnitude of the error signal. An average output voltage, amplified and varying with the error signal, will then act upon the output member. This type of operation gives essentially proportional control, similar to that of a conventional vacuum tube amplifier.

On-Off Control

A simple remote positioning servomechanism using an on-off relay is a typical application of the first mode of operation; although the performance specifications may be tighter than average. A similar line of reasoning may be extended to other feedback systems in this category.

An elementary linear positioning

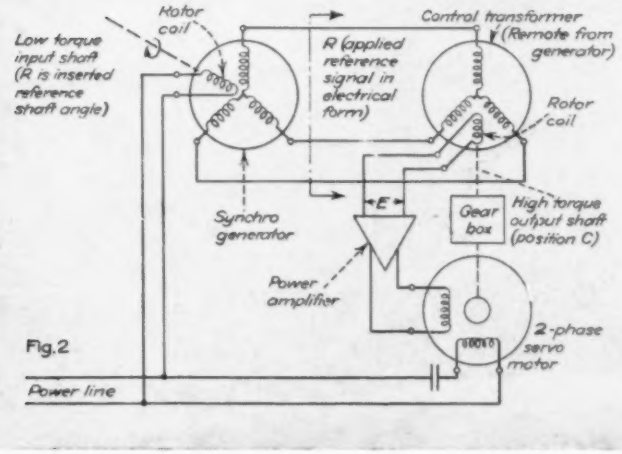


Fig. 2

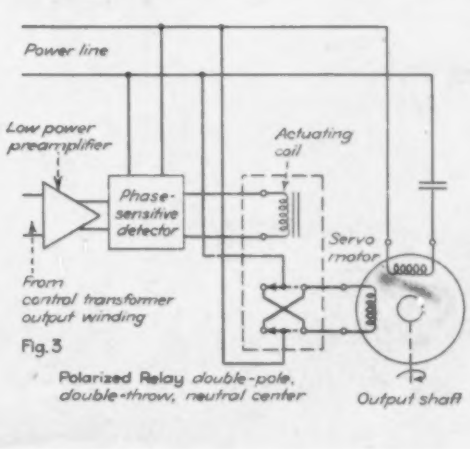


Fig. 3

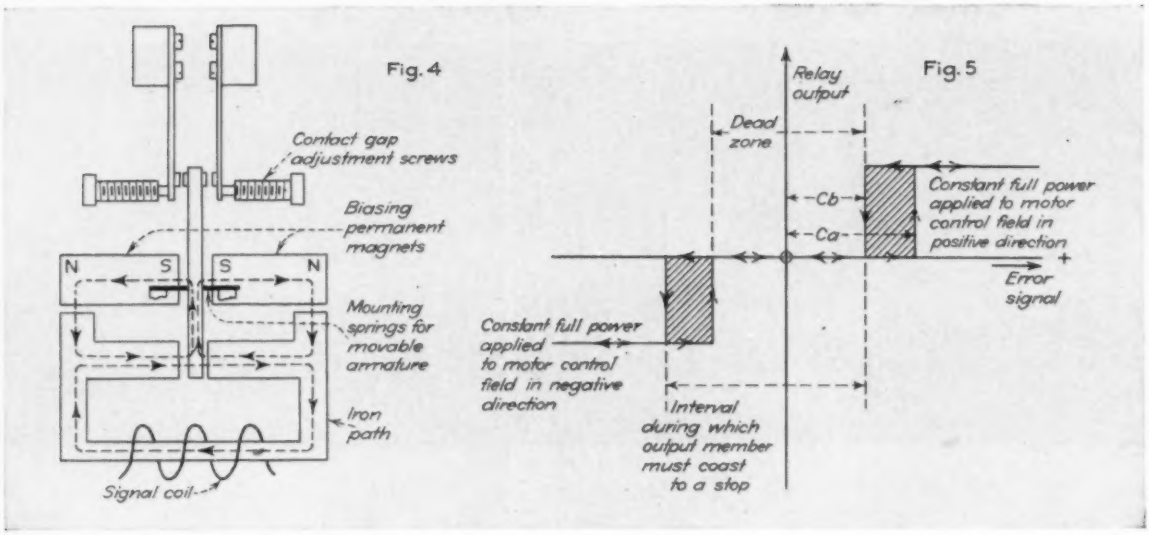


Fig. 4—Neutral center polarized relay. With no coil excitation the balanced armature is in the neutral position. Fluxes from the permanent magnets are symmetrical and the net force on the armature is zero. Application of a d-c signal of arbitrary polarity will cause an unbalance in the fluxes acting on the lower half of the armature. The flux on the left hand side of the armature will be increased, while the flux on the right hand side will be decreased. The lower half of the armature will be pulled to the left and the right hand contact will close. Reversing the signal voltage polarity will close the left hand contact in similar but opposite manner.

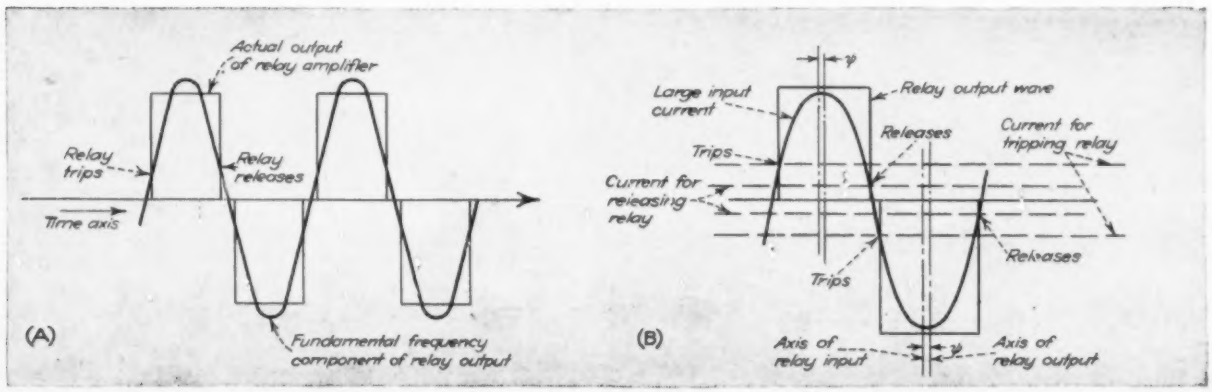
Fig. 5—Relationship between relay output and error, showing the affect of hysteresis or relay stickiness. If the output member drifts from its null position in the positive direction, relay action will follow the dotted arrows and not pull in until the error reaches a value of C_a. Full power will be applied to the output member over the interval $C_a - C_b$, since the relay will not release until C_b is reached. The output member must stop before a negative value of C_a is reached.

servo is shown in Fig. 2. Symbols are the same as in Fig. 1 to show the equivalence of the specific case to the generalized block diagram. The voltage from the output winding of the control transformer is directly proportional to the difference between the input and output shaft positions. The amplified error voltage is applied to the control winding of a two-phase servo motor, which acts to turn the output shaft into correspondence with the input shaft. Usually a stabilizing network (not shown) is inserted just before the motor amplifier to prevent hunting. The amplifier must be capable of supplying rated field power.

In Fig. 3 is shown one possible on-off relay circuit which can be substituted for the power amplifier. Since appreciable power cannot be drawn from the control transformer, a low power preamplifier is usually inserted in the loop. This preamplifier need only supply the actuating power for the relay; a small percentage of the required motor power. Its voltage gain should be sufficient to give the required accuracy in control transformer positioning. Low level preamplifiers are not particularly objectionable, since they are far more reliable than their high level counterparts.

The preamplifier is followed by a phase-sensitive detector which converts the a-c error voltage to a proportional d-c signal whose polarity depends on the phase of the error signal. The d-c voltage is applied to the actuating coil of a polarized double-pole double-throw relay, Fig. 4. The contacts are connected as a reversing switch so that the phase of the alternating voltage applied to the motor control field will depend on the d-c polarity, and ultimately on the phase of the control transformer error signal. When the control transformer error is within a specified limit, the relay contacts will be deenergized.

In practical cases many variations



of this system can be used. A pair of unpolarized relays preceded by suitable rectifier circuits can be substituted for the polarized relay. With a pair of properly driven a-c relays the phase-sensitive detector is not required. The entire system can be operated on d-c, with potentiometers substituted for the synchros and a d-c preamplifier incorporated. Relays can be used in series for greater power amplification. The dynamic relations and stability criteria are the same for these cases and may be extended to a large variety of on-off systems different from this positional servo example.

The nature of the corrective action applied by the motor is a function of the amplifier characteristics. In the linear case of Fig. 2, a displacement of the output shaft from its alignment with the input results in a restoring torque which is proportional to the displacement; within a restricted linear region. The torque acts to restore equality between C and R, and is effective until its value falls below the coulomb or static friction component exerted on the output shaft. A static error may appear in such a system, equal to the maximum torque of coulomb friction divided by the torque gradient of the servo loop.

In the relay amplifier, a dead space appears. The width of this space depends inversely on relay sensitivity and the gain of the preamplifier and phase-sensitive detector; but is independent of shaft friction.

The affect of this relay hysteresis or stickiness is shown in Fig. 5. If the control transformer shaft slowly drifts far enough from its null position to trip the relay, restoring torque is applied by the motor. In the absence of relay hysteresis an infinitesimal torque pulse would be sufficient to return the output shaft to the dead zone, thereby opening the relay contacts. Actually the relay hysteresis requires that the restoring torque act over the prolonged period $C_a - C_b$, and a considerable inertial energy may be imparted to the output shaft during this interval. Unless there is a sufficient amount of damping, the output member will coast until the error exceeds the dead zone limit in the other direction. The relay would then be tripped with the opposite polarity and the cycle repeated. Severe oscillations frequently occur, appreciable relay hysteresis being a major cause of servo instability.

The question of stability may be the determining factor in the choice of a relay amplifier for high accuracy applications. Sufficient damping or frictional torques applied in the interval $C_a + C_b$ may overcome the tendency to oscillate by dissipating the inertial energy accumulated during the application of motor torque. Since dead space and servo error are equivalent, damping must be inversely proportional to allowable error. For small errors, impractical damping requirements may make it difficult or impossible to obtain stable operation. In addition, excessive externally applied damping friction wastes power and reduces the system operating speed. However, a small amount of coulomb friction has been found useful in stabilizing low-power high-precision servos.

Recent investigations have shown that damping techniques which are successfully applied in conventional linear servos generally work for the medium accuracy nonlinear servo. Thus, lead networks, mechanical dampers, and viscous drag may all be carried over to the relay servo. This implies that the usual standards of quality in servo components apply.

A more detailed insight into the properties of the relay as an amplifier may be obtained by applying the frequency response methods developed by Nyquist, Table I.

Assume that a sinusoidally varying

Table I—Fundamentals of Nyquist's Criterion

Nyquist's criterion permits system stability (freedom from self-oscillation) to be predicted in advance, and indicates measures required for improving stability. To use this criterion a polar coordinate plot must be constructed of a complex ratio as a function of input frequency, Fig. 9. The complex ratio is the ratio of the fed-back signal to the sinusoidally varying error in a closed loop system.

If the locus of this complex ratio encircles the minus one point, as the frequency varies from zero to infinity, the system will be unstable. This polar plot may be determined analytically, or experimentally by opening the feedback loop and applying a sinusoidal error of variable frequency.

In the opposite sense, if the minus one point is not encircled by the locus, the system will be stable.

The logic of this criterion can be derived by considering the effects of saturation. As the error is increased in amplitude, finally the fed-back output voltage will level off because of amplifier saturation. Further increases in error will cause inappreciable increases in output, and the output to error ratio will decrease. This will contract the radii of the Nyquist locus.

Eventually a locus which has encircled minus one will cross directly through that point. Thus the fed-back signal is equal in magnitude to the input signal, and when fed back negatively, as in Fig. 1, will have the same phase. Then closing the loop will eliminate the need for the input signal, and self-oscillation will occur at the frequency and amplitude corresponding to the intersection of the function with the minus one point.

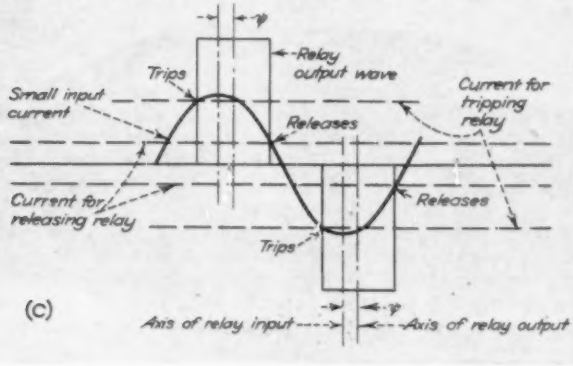


Fig. 6—(A) Output of relay amplifier following a sinusoidally varying error current. As an approximation, only the fundamental component of the output wave will be considered in applying Nyquist's criterion. (B) Relay output for large input current signal. The difference between the relay tripping current and releasing current causes a phase shift, ψ, between the sinusoidal input wave and the square output wave. (C) Small input current causes a larger phase shift than in (B). Thus the relay amplifier has a gain and phase angle with respect to a sinusoidal error which varies with the error amplitude but which is independent of frequency.

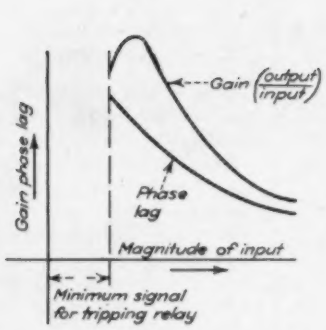


Fig. 7 — Curves show relationship of gain and phase lag to the magnitude of the error signal. Gain rises to a peak and then decreases shortly beyond relay minimum tripping current since relay output is constant once contacts are closed. Phase-lag may approach 45 deg for small signals, but decreases as signals increase as shown in Fig. 6.

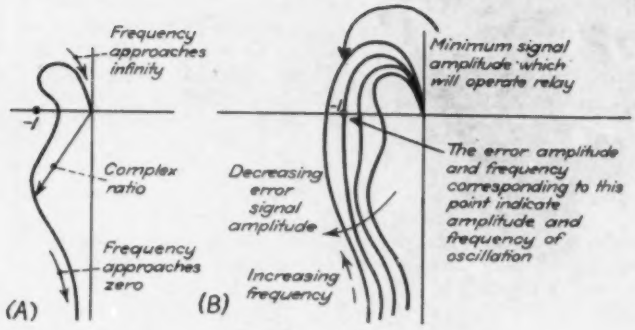

Frequency approaches infinity
Complex ratio
Frequency approaches zero
(A)
Minimum signal amplitude which will operate relay
The error amplitude and frequency corresponding to this point indicate amplitude and frequency of oscillation
Decreasing error signal amplitude
Increasing frequency
(B)

Fig. 8—(A) Open loop transfer function of a stable feedback system for sinusoidal error signal of variable frequency. Complex ratio is the ratio of fed-back voltage to error voltage. (B) Transfer function for a feedback system with relay amplifier. The variation of amplifier phase and gain with error amplitude results in a family of transfer loci, each corresponding to a different amplitude of error. The curves indicate that stability can be obtained by increasing the error amplitude required to actuate the relay, i.e,, reducing the system gain.

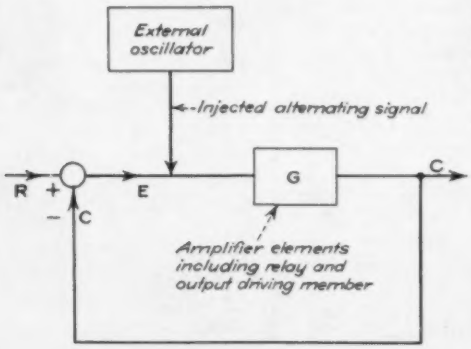


Fig. 9 — Basic feedback system using a relay as a proportional amplifier. The inertia of the output member does not permit it to follow the high frequency of the injected signal. It will, however, react to a slower varying error signal which is superimposed on the signal obtained from the external oscillator.

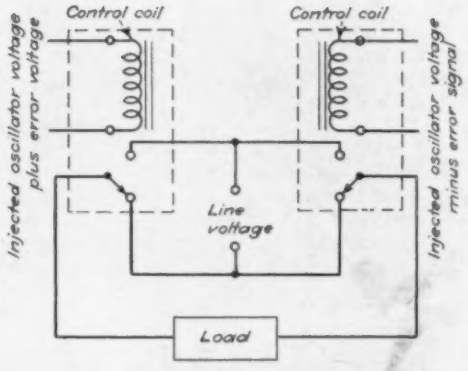


Fig. 10 — Two single-pole, double-throw relays connected as a proportional amplifier. This system is more efficient than that shown in Fig. 9. Power output is obtained only when the oscillator contacts are not exactly synchronized. An injected error signal will yield unidirectional pulses of output energy, with pulse width proportional to the magnitude of the error signal. Electronic Instruments; Greenwood, Holdam, and Mac Rae, McGraw-Hill Book Co., Inc., 1948.

error signal is applied which is large enough to trip the relay for some portion of each half cycle. If the transit time of the armature is neglected, the output will be a square wave, Fig. 6 (A). Only the fundamental component of the output is considered.

Because of relay hysteresis, a phase shift or time delay is introduced between the fundamental frequency output and input waves. In Figs. 6 (B) and (C) are shown the output waves for very large and very small errors respectively, and the corresponding fundamental components. In the case of large error, the high rate of increase and decrease of the error signal cause the phase shift to be small even though relay hysteresis causes a current differential between the tripping and release points. With a small error, the slow rate of signal increase and decrease magnifies the affect of hysteresis and causes a large phase shift.

Thus the relay amplifier has a gain and phase angle, Fig. 7, with respect to a sinusoidal error, which varies with the error amplitude but which is independent of frequency.

The application of Nyquist's criterion can now be derived. In place of the usual frequency response characteristic or transfer function, a family

of characteristics is required, each corresponding to a different amplitude of error signal. That is, the single curve of the conventional linear system must be replaced by a family of curves because of the variation of complex gain with amplitude.

In the linear case the servo will be stable if the curve, Fig. 8 (A), does not encircle the Nyquist point. In the nonlinear case, if any curve, Fig. 8 (B), passes through the Nyquist point, the servo will oscillate at the corresponding frequency and amplitude. The servo designer should apply the usual techniques for shaping transfer characteristics to the limiting curves of the family to prevent encirclement of the Nyquist point, thereby insuring stability.

For the highest accuracy, stability may be difficult to achieve using strictly linear elements. For this purpose a variety of nonlinear techniques have been devised. One example is the use of coulomb friction damping. A practical design procedure might consist of getting the best possible performance using only conventional linear damping methods, then improving the quality by the introduction of nonlinearities.

Some compact systems have been built in which the relay dead space was eliminated so that no stable equilibrium position existed. This causes continuous servo oscillation of high frequency but sufficiently small amplitude so as not to impair accuracy. This arrangement is used in regulators and similar systems. In large systems, the high frequency oscillations cause excessive wear in gearing, relay contacts, and other components.

When a positional servo of the on-off type is continuously varying its heading, the output will not have the smooth characteristic of a proportional servo. Instead it will move in a series of discontinuous steps, of the order of magnitude of the relay dead space. While the lack of smoothness in itself may not introduce excessive error, such irregular following may be unsuitable for some applications, particularly where a human operator is employed in conjunction with the servomechanism. In this case, relays may be operated in the alternate mode mentioned previously, in which approximately proportional control is obtained.

Proportional Control

A relay with continually vibrating contacts can operate as a nearly linear amplifier. In Fig. 9 is shown one way in which the basic feedback loop of Fig. 1 can be modified to accomplish this.

Assume zero error. An injected alternating signal, of relatively high frequency compared to the natural frequency of the system, will cause the relay to chatter, alternately applying positive and negative corrections of equal magnitude to the output member. The output response will be a slight vibration at relay chatter frequency.

When an error signal is applied to the system, the positive and negative alternations of relay output will no longer be of equal magnitude. A small positive error will cause the positive relay contact to remain energized during a larger portion of the cycle than the negative contact. Averaging over many cycles, a net positive energy will be applied to the output driving device to correct the error. Similar reasoning applies to the case of a negative error.

Proportional control is obtained for error signals having a smaller amplitude than the carrier. For large errors, the relay remains continuously energized with the proper polarity and chattering ceases. This permits rapid slewing when large shifts in the variable settings are required. Since maximum correction is applied when the error signal equals the injected oscillating voltage, and since this maximum correction is constant, reducing the injected voltage will increase the sensitivity of the system to error, or equally, will increase system gain. This is a

Table II—Typical Specifications of Relays Suitable for Automatic Control Applications

Manufacturers Specification	Sigma Type 7JO X	Western Electric mercury contact Type 276D	Electric Regulator Corp. standard Regohm
Relay type	Single-pole, double-throw, neutral center, polarized	Double-pole, double-throw, no neutral position, polarized	Multiple fingers, polarized, 10 contacts operating in sequence as d-c signal is applied, available normally open or normally closed.
Response speed	0.001 to 0.007 sec	0.003 to 0.005 sec, can follow signals up to 100 cps	Can follow signals up to 400 cps
Power rating of contacts*	2 amps, 24 volts d-c, or 115 volts a-c for resistive load, 100,000 operations	250 volts by 5 amps resistive load, 1,000 million operations	12 watts per contact, 10 million operations, higher power contacts available.
Approximate control power to energize contacts	1 milliwatt	4 milliwatts	With about 1 watt of d-c bias it can be controlled by variations of less than 10 milliwatts.
Operating temperature range	85 C max. internal temperature, 1.5 watts dissipation in coil is equivalent to 40 C rise. operates at −60 C	From −37.8 F (freezing point of mercury) to a max. of 170 F internal temperature; rise is 35 F per watt above ambient	Unit is compensated to operate over a wide temperature range.
Environmental characteristics	Hermetically sealed	Hermetically sealed	Available hermetically sealed
Weight	7¼ oz	4 oz	6 oz
Special features**	Ideal for control applications, rugged and balanced for operation under severe conditions as in aircraft.	Relay axis must be maintained within 30 deg. of vertical because of mercury reservoir	Available with 20 contacts also; includes a spring plus dash pot coupled to the moving armature for stabilization purposes

* Contacts must be derated for control of highly reactive loads. Operation below rating can result in increased life. Where required special contact materials are generally available. It is assumed that suitable spark suppression circuits are used.

** These relays are all of the plug-in type, permitting easy servicing and replacement.

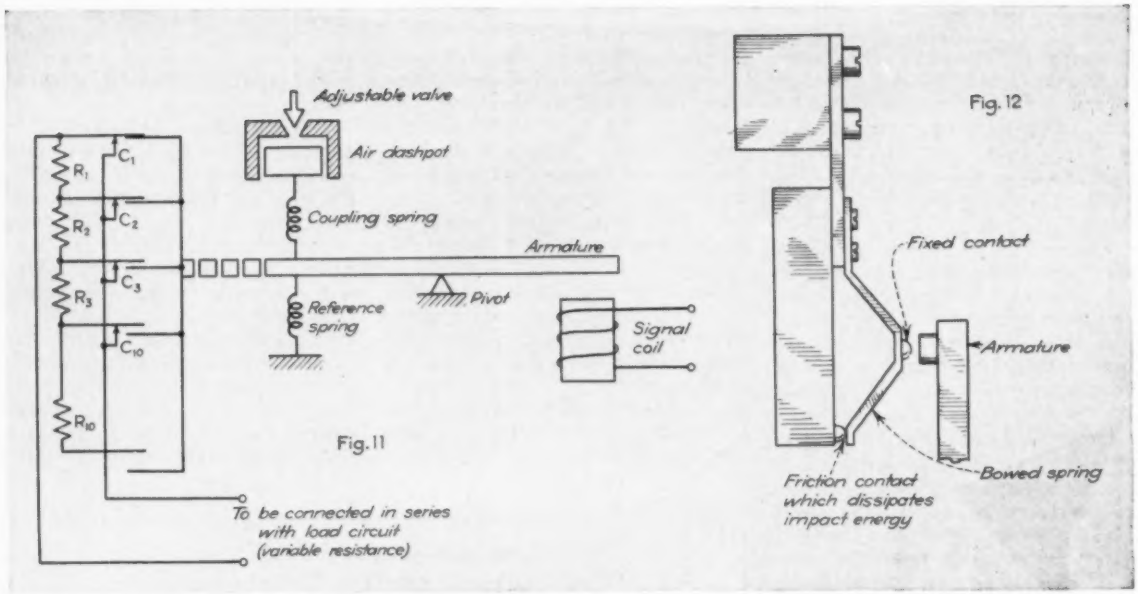


Fig. 11—Schematic of Regohm relay. The application of a d-c signal causes the armature to pivot. The contacts C_1 to C_{10} open sequentially, gradually inserting resistance in series with the load circuit. Models are available in which a signal will close the contacts, thereby cutting out resistance. The dashpot and springs give high sensitivity to signal current fluctuations about some critical value. This enables accurate regulation of an electrical quantity, and gives simple stabilizing means for closed loop systems. In normal operation, the armature will oscillate between two adjacent contacts, yielding an average value of load circuit resistance with a minimum of stepping action.

Fig. 12—Detail of contact mounting on Carpenter polarized relay Type 5; manufactured by Telephone Manufacturing Company Limited, London, England. This method reduces contact bounce by mechanical damping. Also, the armature comes to rest quickly after contact closure and prevents extra detrimental oscillations.

convenient method for varying gain. The injected voltage must always be sufficient to operate the relay in the absence of error.

There are many circuits for obtaining proportional control without requiring an external oscillator. These are based on feeding some of the relay output energy back to its control coil. Oscillations will be set up similar to those frequently occurring in high gain feedback amplifiers, causing the relay to chatter. This technique is not as flexible as the previous one, but a separate oscillator is avoided.

Both of these methods for obtaining proportional control waste power, cause heating in the output member, and place a heavy burden on the relay contacts. This follows from the mode of operation, which yields a useful output as the difference between two large balancing outputs. The inherent poor efficiency restricts application to low power systems.

A more efficient proportional control circuit is shown in Fig. 10. Two single-pole, double-throw relays are connected so that when the error signal is zero, both relays oscillate in synchronism. The moving armatures touch the upper and lower contacts together, and by symmetry no line voltage is applied to the load. Thus under zero error conditions the oscillating contacts do not break any line current.

When an error voltage is generated, it adds to the injected oscillator voltage of one relay, and subtracts from the injected voltage of the other. This unsynchronizes the armatures so that for limited portions of the cycle they rest on opposing contacts at the same time. The voltage applied to the load is roughly proportional to error signal until maximum output is reached. This circuit avoids most of the faults of the previous ones.

A useful proportional control circuit based on multi-fingered relays has been successfully applied. Relays such as the Westinghouse Silverstat or the Regohm of the Electric Regulator Corp., Fig. 11, are two such devices. These have several contacting fingers which gradually cut out or insert successive steps of impedance in an electric circuit with the application of an error signal. This results in a gradual application of voltage to a load.

Since each contact makes or breaks only a fraction of the total current, long spark free life is obtained even with highly inductive loads. In many circuits no spark suppression elements are necessary.

Elements such as the Regohm, Table II, can control up to 100 watts in less than 5 cubic inches. Higher ratings are also available. The device is temperature compensated and can serve as a high quality regulator by applying error voltage to the control winding. The contacts assume an equilibrium position, cutting in just enough circuit resistance to reduce the error. Where the discreet steps of the output do not allow an exact balance, control will alternate between adjacent contacts oscillating at high frequency. The average position performs an interpolation function. The Regohm incorporates a spring dashpot arrangement, which smooths out the dither in the output and inserts lead or anticipation in a control loop. This simplifies stabilization. The principal disadvantage of this type of control is the need for additional external impedances to be connected across the contacts.

Other control relays include the mercury contact type and a new novel semi-conductor type.

In the mercury contact relay, a reservoir of mercury and capillary action give a continuously renewed protective coating on the contacts, resulting in clean breaks, high capacity, and long life, with no deterioration of the contact metal. The Western Electric models 275 and 276 are available as

hermetically sealed units. They have high speeds of response and good stability of operating characteristics. The main disadvantage is the necessity for operating in a vertical or nearly vertical position.

The properties of semi-conductor relays are such that triggering can be caused by the application of very small signals. Up to 40 watts have been controlled, and it is likely that larger sizes will be developed. The freedom from arcing, together with the long life, ruggedness, compactness and efficiency characteristic of semi-conductor components, may ultimately cause this unit to be favored in comparison with conventional relays.

Proportional control permits higher accuracy and smoother following than the on-off type of control. Relay stickiness does not introduce phase-shift problems and conventional stabilization methods apply. On the other hand, with on-off control the circuit current is not interrupted as frequently and relay life is increased. Also faster response can be obtained. In particular the on-off circuit is to be preferred in medium or low accuracy systems with slowly changing variables. A comparison of proportional relay control with conventional linear operation shows that almost equivalent dynamic performance can be assumed. Thus the choice depends on such factors as economy, life, and compactness.

Relay Selection

The major factors influencing relay choice are the requirements of the circuit and load, speed of operation, life, and ambient conditions. The nature of the circuit being controlled will dictate the arrangement of contacts and the sequence of opening or closing. Relay life depends on load and ambient conditions. When deviations from standard manufacturer-specified operating conditions are required, joint consultation is advisable.

Usually, a-c operation does less damage to the contacts than d-c operation because of the latter's tendency to sustain an arc. A-c volt-ampere ratings may be several times the d-c rating for equal life. All specifications of life assume that appropriate spark suppression circuits are used. Contact sparking can increase appreciably in the rarified atmosphere of high altitudes, and hermetically sealed units should be used under these conditions. This construction is also recommended when humidity, fungus, corrosive atmospheres, and dust tend to reduce operating life.

The evaluation of load requirements is generally concerned with transient rather than steady state circuit voltages and currents. The initial inrush current of a cold incandescent bulb or the voltage peaks of highly inductive circuits can be more significant than the normal circuit ratings would indicate. The mechanical hammering of contacts on closing is a wear factor which can be as important in some applications as the electrical pitting of contacts. Since the force exerted on the relay armature varies as the square of the control current, frequent large surges in this current should be avoided. In d-c circuits, the unidirectional quality of the current flow often results in unequal wear on the positive and negative contacts.

A convenient feature of the relay as a control element is the free choice of control winding impedance. Manufacturers usually provide lines of identical relays with variations in control coil turns. This gives the user a wide choice of values. Usually it is possible to couple relays directly into circuits without isolating or impedance-matching elements. Thus a relay can be put directly into the plate circuit of a d-c amplifier, with the quiescent plate current serving as a bias.

Relay inductance is important in circuits where speed of response is a factor. Since a variable air gap exists in a relay, the actual coil reluctance depends on armature position. A momentary reduction of control current takes place during closing because of the counter electromotive force generated by an increasing inductance. The ratio of maximum to minimum inductance can be as high as two or more to one.

In calculating the time constant of a control coil it is safest, and on the conservative side, to take the ratio of maximum inductance to effective circuit resistance. This time constant is an indication of the time required to build up exciting current in the control winding, and is related to the minimum response time of the feedback system.

The fact that it is control current and not applied voltage which promotes relay operation is important. This should be considered when designing relay circuits, since shunting capacitors, series inductors, and resonant conditions all tend to delay current build-up.

In high speed on-off systems, relay stickiness is a factor which affects choice. Best performance is obtained when the hysteresis is under 20 to 30 percent of the dead space. Unfortunately, relay designs which are rugged and have stable characteristics also tend to have high hysteresis.

Relay armature transit time is frequently appreciable in high speed systems. Transit time is greater for small applied control signals since the forces which accelerate the moving armature are reduced. This is the normal operating condition for feedback systems since the relay must respond to small error signals.

Another factor which can reduce relay life in high speed on-off systems is contact bounce. This causes the actual number of cycles of operation to be much higher than is theoretically expected. Large magnetic forces exerted on the moving armature will cause bounce unless provision is made for dynamic damping. The sudden application of a large control current from a high impedance source, such as is required for rapid operation, will cause bounce since the source impedance prevents the current reduction associated with the closing of a relay. In Fig. 12 is shown a mechanical damping arrangement used on Carpenter relays for dissipating the kinetic energy of the moving armature. Bounce can also be prevented by the use of short circuiting coils which are magnetically coupled with the control coil. This adds an additional time delay, but is frequently a satisfactory method.

Small sensitive relays are available which are capable of following 60 cycles, 400 cycles, and even higher frequencies. With relays of this type, frequencies should not be introduced which are close to the mechanical natural frequency of the armature, or any of its harmonics. Erratic operation usually results from such a coincidence of frequencies.

For example, a sensitive polarized d-c relay may respond to the 400 cycle ripple present in the half-wave rectified d-c output obtained from a 400 cycle signal source. Lower resonant frequencies may be introduced by mechanical vibrations caused by machinery in the vicinity of the relay. The chatter frequency in proportional control circuits must be selected to avoid all resonant conditions.

In large relay sizes, these high speeds are unobtainable. However, the equipment controlled by the relay will respond more slowly and the relay response time can usually be neglected.

The variety of useful relay circuits is so great, and modifications in design so readily obtainable, that many manufacturers will make up relatively inexpensive special relays to suit particular applications. In many relays the contact gap (and thereby sensitivity) or damping can be adjusted to meet re-

quirements. Some relays have removable contacts to permit a choice of circuit connections. Contact materials can be chosen to meet loading conditions.

Small relays are also available which can be actuated by a few microwatts of input power. These are often constructed in the form of a conventional d-c meter, with a contacting element attached to the moving pointer. An adjustable stationary contact permits relay actuation to occur at any point on the full scale of the meter. Such devices are usually used in slowly varying regulating systems, where the low input power level eliminates the need for a preamplifier. The output can actuate a larger relay of sufficient capacity to drive a heavy load.

Preamplification devices incorporating thyratrons, vacuum tubes, magnetic cores, transistors, and rectifier circuits permit the use of a large variety of relay types with a wide range of system gain adjustment.

Arc Suppression

The arc suppression problem is peculiar to relay and contactor devices and must be considered if maximum contact life is to be obtained. Although contact transients depend on the characteristics of the circuit external to the relay, and must be studied separately for each application, an example will illustrate the characteristic features.

Three different techniques for suppressing contact sparking in an inductively loaded circuit are shown in Fig. 13. (Spark suppression presents no problem with resistive loads.) In (A), a series resistance-capacitance network is placed across the contact. During steady state operation these elements have no influence on the circuit. Upon opening the contact, the collapsing flux lines around the load inductor tend to maintain the decaying current, thereby generating a counter voltage. This must be added to the supply voltage, yielding a total voltage across the unprotected contact which can be many times the supply voltage. The uncharged capacitor is selected to reduce this voltage to a safe value. It acts as a cushion across the contacts, absorbing much of the circuit energy until that energy is dissipated in the resistive elements.

On closing the circuit, the capacitor (now charged to full line voltage) will discharge through the relay contacts. Maximum current is limited by the resistor to avoid contact welding. Thus, the condenser is selected to limit the peak voltage on opening the circuit, while the resistor is chosen to limit the peak discharge current.

In low impedance circuits, bulky arc suppression capacitors would sometimes be required and the alternate circuits of (B) and (C) are suggested.

In (B) a half-wave selenium rectifier is placed across the load. With the contact closed, the rectifier draws neglible power from the line because of its high inverse resistance. However, upon opening the contact, the inductive current will flow in the forward direction of the rectifier thereby dissipating the inductive energy.

The arrangement shown in (C) is a recent development in arc suppression. Two selenium cells are mounted back to back across the inductive load. Under steady conditions they draw no current from the lines. Under surge conditions the voltage which develops across the inductance may exceed the peak inverse voltage of the nonconducting rectifier. This rectifier would then break down in the reverse direction, limiting the sparking voltage. Rectifiers are commercially available for this application.

A properly applied relay should have a useful life comparable with that of the electrical equipment normally found in industrial plants. Many thousands of hours of unattended operation are obtainable with proper care. In contrast to vacuum tube or gas tube equipment, relay failure can be anticipated by periodic contact examination. Blowing out particles of pulverized metal, or burnishing a corroded contact can sometimes extend relay life considerably. Because of the inherent economy of a relay, occasional preventive replacement may be warranted.

The switching action of the thyratron is analogous to the operation of a contactor device. A large variety of thyratron circuits can be designed which are similar to the contactor circuits. In general under 300 or 400 volts and several hundred watts, the relay is favored because of better reliability, lower cost, and simplicity. Above these ratings or with rapid switching heavy inductive loads, the thyratons are preferred. Each case requires individual treatment, however, and contactor servomechanisms have been used in the integral horsepower range.

EDITOR'S NOTE: An article covering typical amplifier relay circuits for control applications will appear in the April issue of *Product Engineering*.

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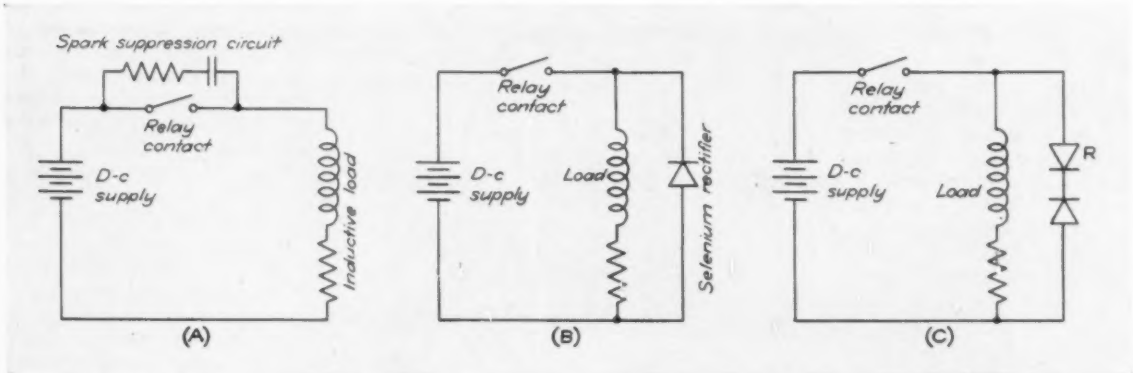
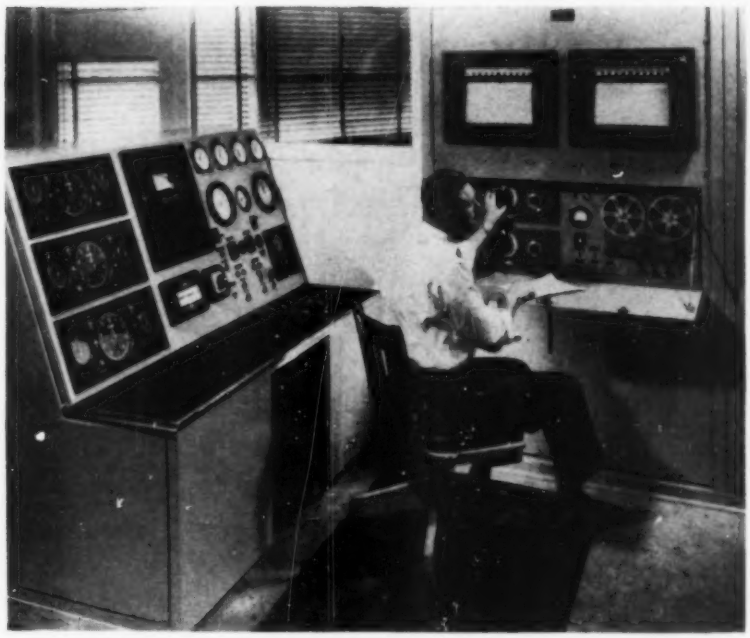


Fig. 13—Three typical spark suppression circuits. In (A) the condenser is selected to limit the peak voltage across the contacts on opening the circuit, while the resistor is chosen to limit the peak discharge current. When required capacitor is bulky, (B) or (C) might be used instead. In (B) selenium diode only carries current during opening of switch and decay of inductive current. Rectifier *R* in (C) breaks down under excessive peak voltage and limits voltage across contact to a safe value.



OPERATING THE AUTOMATIC CYCLING CONTROL PANEL at Alden Indoor Proving Ground of Timken-Detroit Axle Co. Console at left used to set up test.

Electronic "Brain" Controls Lab Tests

AN INDOOR TESTING LABORATORY, demonstrated by Timken-Detroit Axle Co. at the annual meeting of the SAE in Detroit, reproduces actual operating conditions found on standard outdoor proving grounds.

Designed and built by the General Electric Co., this new driving axle testing equipment supplies several important performance predictions:

- The number of load cycles on axle housings before failure.
- The number of stress reversal cycles on axle shafts before failure.
- The number of input pinion cycles on differential carrier units before failure.
- The ouput and efficiency of the brake.

Other potential uses for the equipment include stress analysis of parts under simulated operating conditions, measurement of lubricity of various lubricating oils, and calculation of vibration or sound.

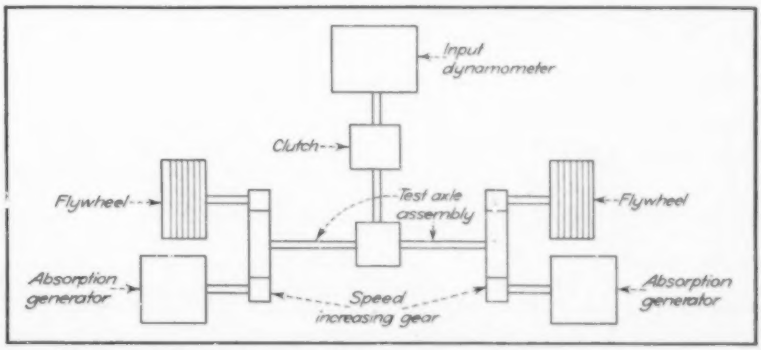
Essentially, the test equipment is made up of three basic parts: (1) Input dynamometer having a motoring rating of 4550 lb ft from 0 to 400 rpm and constant horsepower from 400 to 3,000 rpm; output dynamometers having an absorption rating of 22,700 lb ft from 0 to 50 rpm and constant horsepower from 50 to 570 rpm as well as having an inertia equal to 40,000 lbs of truck weight for a 46-in wheel dia; (2) 500 hp motor, 750 kw generator, (3) electronic automatic cycling equipment. The test stand is shown schematically below.

Perhaps the most novel feature of the entire system is the automatic cycling equipment, (next page). Operation of the equipment is as follows: Brown strip chart recorders indicate and record speed of the input dynamometer and torque of the absorption machines. The tape recorder, surrounded by oscillators, amplifier, discriminator, reversing unit and power supply, has two separate recording channels located side by side on the magnetic tape. One track is contacted while the tape moves from right to left and the other track is contacted when the tape is moving from left to right. Automatic change of direction at either end of travel repeats the test again and again without shutting down the equipment. The maximum duration of a single operating sequence is two hours.

Speed and torque as well as a signal for reversing the direction of the tape are carried on one channel of the magnetic tape by superimposing various frequencies.

During the recording operation, these signal frequencies obtained from the oscillators are 300 to 900 cycles per second for torque, 3,000 to 6,000 cps for speed and 1,500 cps for reversing. When the original test is duplicated during playback, the discriminator separates the frequencies by means of filters and converts them back into signals of speed and torque.

The operator sets up any testing sequence desired by design or test engineers by controlling the reference voltages of the speed and torque regulators while the cycling control records the voltage values. During playback, control is taken away from the operator. By means of this cycling control a given test may be duplicated months



ARRANGEMENT OF the Test Stand during normal operation.

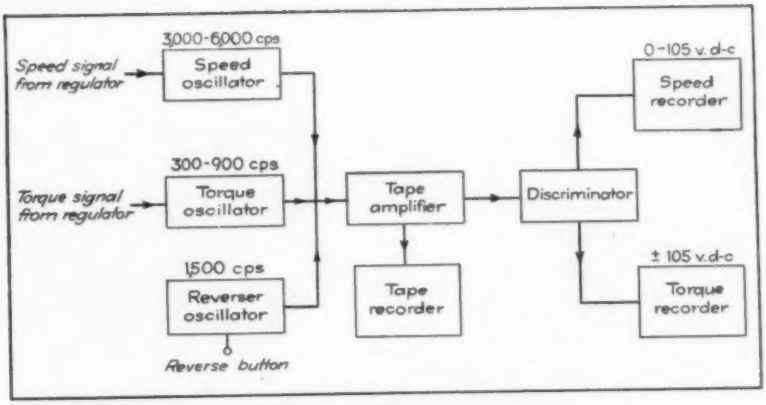
after an initial test is made without the possibility of human error.

Located between the input dynamometer and the axle is a combination flywheel, reduction gear and clutch. The heart of the equipment when used for shock loading is the clutch, Fig. 4. The splined sleeves at each end of the unit and positioned by levers, are shown in the disengaged position. During normal testing the sleeve at the input end bridges the splines on the input and output shafts so that power is transmitted straight through the unit without the use of the clutches or the flywheel.

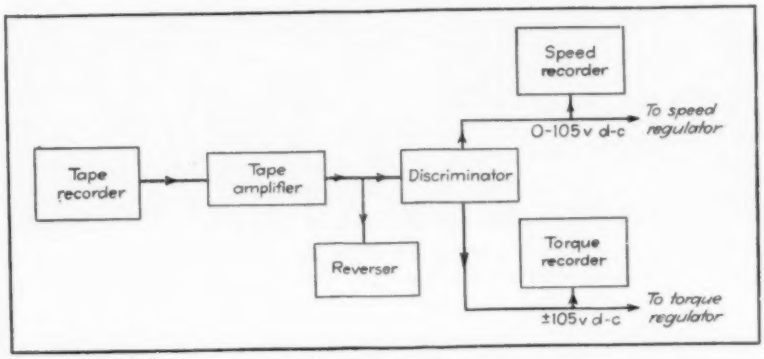
Mounted on hollow shafts are the clutch plates and the planets of the gear unit. The clutches are spring-closed and are opened by means of air cylinders controlled by solenoid valves. During a shock loading test the splined sleeves are moved to connect the input shaft to the input clutch and the output shaft to the planet carrier. The clutch operation during a shock test is as follows:

All dynamometers are at rest at the beginning of the cycle with the input clutch engaged and the output disengaged. The operator brings the input dynamometer up to speed. The operator, from the console, starts the cycle by means of a switch. First, the input clutch is disengaged, and then the output clutch is suddenly engaged. The flywheel mounted between the clutches simulates engine inertia and its stored energy is transmitted through the output clutch and planetary gear to the axle and hence to the output flywheels. The magnitude of the shock loading depends upon the speed of engaging the clutch. When the clutch becomes completely engaged, the entire assembly is operating at low speed and that cycle is complete.

The entire test system duplicates the service of a truck carry a 38 ton load and traveling at a speed of 60 mph. It has a cycling system enabling it to follow a set course of variable speeds and torques, and will repeat a given sequence time after time.



BLOCK DIAGRAM of Cycling Control during recording.



BLOCK DIAGRAM of Cycling Control during playback.

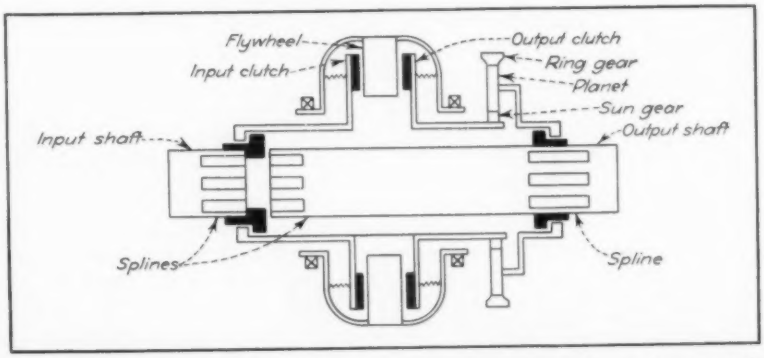


DIAGRAM OF INPUT CLUTCH and flywheel unit. Splined sleeves shown solid.

Manpower Program Set-Up for 1953

AGGRESSIVE MANPOWER PROGRAM to insure the availability of enough engineers and scientists to serve the nation's needs is the Engineering Manpower Commission's plan for 1953, according to T. A. Marshall, Executive Secretary.

He declared that there is a demand for 40,000 new engineering graduates right now and grim estimates for the next four years show an average of only 23,000 graduates yearly. To combat this shortage, the Commission plans a three-fold program: (1) to establish the importance of engineering to the public welfare; (2) to aid in maintaining the supply of trained engineers; and (3) to promote most effective use of engineers in the national health, safety and interest.

Concrete steps to be taken: stress better utilization of engineers by government and industry; determine actual need for engineers in military services; encourage service released engineers to return to engineering occupation; press for amendment of Armed Forces Reserve Act; step-up interesting high school students in technical careers; actively assist organizations with current information on engineering manpower situation.

Transistors Enter Commercial Field

RAYTHEON MANUFACTURING COMPANY is shipping over 10,000 junction type transistors a month to hearing aid manufacturers for use in new transistorized hearing aids. Although two or three other companies will also supply transistors in production quantities, Raytheon believes no other company is producing such a volume.

According to Norman B. Krim, Raytheon Vice-President, hearing aids are the first marketed products to use the tiny germanium semi-conductor devices. Five manufacturers have already announced transistor hearing aids; twenty more will make similar announcements in the next few months.

In the new hearing aids, transistors replace anywhere from one to three vacuum tubes (total number of tubes in the device is three). A completely transitorized hearing aid costs about one and a half times a vacuum tube aid.

Major advantage of the tubeless devices in this application is economy for the user and a reduction of maintenance. Vacuum tube aids operate on two batteries, an A and B. Replacement costs of these run about $40 a year. The tubeless aid uses only an A battery since it needs no filament currents, supplied by the B battery. And because the transistor circuit drains only about 5 milliamps compared to 20-25 ma for a vacuum tube unit, batteries last longer so that replacement costs are cut to three dollars a year.

Krim predicted that it will be two or three years before transistors find their way into other commercial products like radios or television sets. The big obstacle—cost. Raytheon sells junction type transistors for about nine dollars a piece, hardly competitive with a vacuum tube that may cost as little as a dollar and a half.

Main items in the high cost are the large quantities of hand labor involved in manufacture, and the expense of germanium metal itself. To solve this price problem, Raytheon has at least three different development programs underway: 1) to develop machinery that will make transistors automatically; 2) to develop satisfactory transistors that use less germanium than present production models; 3) to develop new semi-conductor materials, both metallic and non-metallic, that will replace the high priced germanium metal.

The Raytheon Vice-President also cautioned that users will have to make careful application of transistors because they are still not fool-proof. He pointed out that the hearing aid application had been developed only after two years of laboratory work. Proper design had taken care of some of the vagaries of transistors.

But for other applications, transistor malfunction under thermal or mechanical shock, limited frequency response, and limited capacity might make them unsatisfactory.

Krim sees a big future for transistors once the price has been brought down. Next application: portable radios. Laboratory men claim that midget portables with the germanium devices completely replacing vacuum tubes have already been successfully tested in the laboratory. Only the high cost prevents marketing.

Other products in the experimental stage include: transitorized automobile radios, phonographs, computer components, and miniature radio and television transmitters.

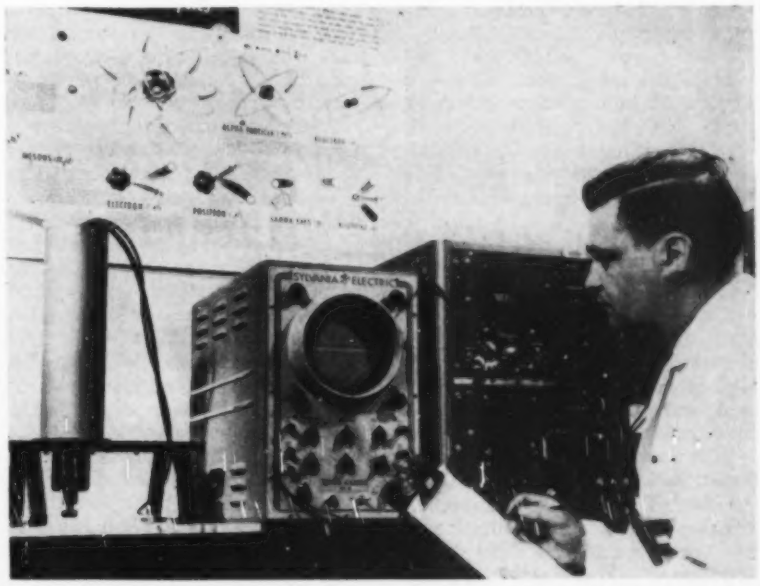
There are many industrial applications that will be able to use transistors too. Probably the biggest field is instruments and their controls. Krim feels that combination vacuum tube and transistor circuits will be the most useful in industry. Because of their limited power carrying capacity, it is doubtful that transistors will be able to replace tubes completely.

Radioactivity Speeds-Up Industrial Research

GERMANIUM RESEARCH is accelerated by the use of a radioactivity method known as activation analysis. Based upon the availability of radio-isotopes and services of nuclear reactors, Dr. G. H. Morrison of Sylvania Electric's Central Engineering Laboratory told members of AIEE recently that it is now possible to measure impurities of one part in 100 million. According to Morrison, conventional chemical methods of measurement are ineffective at such low concentrations.

Sylvania's specific application of the radioactivity method is the evaluation of trace amounts of impurities that are transferred from the germanium processing container. First step is subjecting the graphite container to nuclear radiation during which certain impurities of the graphite are made radioactive. During processing of the germanium, a portion of the container impurities are transferred to the semiconductor material. Since impurities are radioactive, quantity and identity are determined by measuring intensity and decay rate of radiation.

Morrison stated that Sylvania's development of radioactivity as a research tool was made possible by nearness to AEC's Brookhaven reactor.

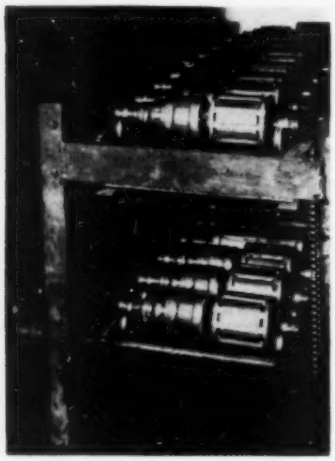


RADIOACTIVE METHOD to determine trace amounts of impurities in germanium being evaluated by Sylvania Electric technician in company's Bayside, New York, laboratories. Primary use is to carry on research in semi-conductor materials.

Polyesters Speed-Up Motor Production

POLYESTER RESINS used instead of silicone or phenolic resins to impregnate electrical windings in motor stators and rotors cut processing time from 70 to four and a half hours. And a simpler manufacturing technique reduces costs and number of rejects.

Eclipse Pioneer Division of Bendix Aviation Corporation developed the process using American Cyanamid's Laminac resin to insulate rotors of high speed aircraft generators against arcing and moisture. The plastic also anchors the windings in place despite the centrifugal forces generated by high speed rotation.



POLYESTER treated aircraft generator rotors in special rotating fixture for oven curing at 300 deg F.

Major advantage stems from a reduction of impregnation and curing time. With the polyester resin, the windings are impregnated in a vacuum of 20 in. of hg for 10 minutes. Initial curing takes one hour; final drying another 3 hr.

Other advantages claimed for the technique: the polyester resin does not "gas" at high altitudes as phenolics do; it withstands higher temperatures than silicones before softening; it eliminates three coats of varnish usually applied when other resins are used; and it does away with the need for post-cleaning.

When rotors are being processed, they are rotated during the initial curing so that the resin gels uniformly and does not unbalance the rotor. Stators can be cured and dried in one operation.

The new impregnating technique cuts rejects from a rate that previously ranged 40-50 percent to 10 percent.

Shell Molding Uses More Resin

A SIGNIFICANT TREND in the use of the shell mold process is earmarked by the upswing in phenolic resin production for the foundry industry.

Monsanto Chemical estimates that due to developments in casting procedures industry-wide volume of phenolics will climb to more than 17 times the 1952 figure.

First major use of phenolics for process dates back only to 1950. Today, production is calculated at rate of several million pounds annually.

It is also pointed out that a basis of measurement of shell mold growth should be the number of molding stations in operation. Most units are multiple station types varying from 2-24. In 1952, approximately 300 stations were in operation; by end of 1953 over 900 stations will be making casting shells.

Research Costs Mount

WASHINGTON—The Industrial research and Development Board's Preliminary Report shows that the nation is stepping up its industrial research program. In 1952, the total outlay was about three and one-half billion dollars—four times the yearly bill at beginning of World War II.

Manufacturing concerns are doing the bulk of the research with electrical machinery, aircraft and chemical industries accounting for one-half of the work. But the Federal Government is picking up at least 50 percent of the cost, principally by the Defense Department and Atomic Energy Commission.

Cost of research for companies is running at a rate of about two percent of annual sales or services. Industry proportions vary widely with aircraft manufacturing up to 13 percent; electrical machinery and professional and scientific instruments at 6 percent, to 0.6 percent in petroleum refining and the primary and fabricated metal industries.

The RDB report states that the average cost per research engineer or scientist is $22,100. Motor vehicle industry's cost is over $68,000, and the chemical industry's outlay is down to $16,500. Wide differences are due to varying ratios of engineers and scientists to supporting personnel. Average ratio is nearly one scientist for every five supporting workers. However, higher ratios are explainable in light of research organizations expanding their staffs to utilize professional personnel more efficiently during current manpower shortages.

Turnover rate of engineers and scientists leaving research jobs for other positions or service in the Armed Forces is approaching the World War II level. Current figures show that 16.4 out of 100 professional people employed are leaving their jobs every year. In the aircraft industry, competition for engineers and scientists boosts the separation rate up to 20.8 per 100.

Call-ups for military service show a rate of only 3 per 100 workers, of which Reserve calls made up 1.8 and Selective Service 1.2. But alarming figure is that almost 20 percent of all research personnel are members of Reserve Components and thus liable for recall. Another 6 percent are classified 1A or 2A. In the electrical machinery industry about 34 percent of the professional staff is vulnerable to military service; in the aircraft industry, 29 percent.

Another interesting point made by the report is the indication by industry that they were able and willing to take on additional research contracts which implies a reservoir of scientific personnel that can still be utilized.

Device Detects "Micro-Heat" Changes

A MICROCALORIMETER developed by the University of Chicago's Institute for Study of Metals detects temperature changes as small as 0.0003 C. Projected use of the device is to analyze basic structural changes within metals that effect their properties.

Heat measuring apparatus consists of two basic parts: a vaporthermostat to maintain a constant temperature around the object whose heat is being measured, and the actual heat measuring device which induces a minute electric current resulting from temperature difference between the constant temperature of the vaporthermostat and the temperature of the sample.

Vaporthermostat includes heating units, condensers, and shielded constant pressure reservoir insulated by a closet-size container of sawdust. Methyl benzoate provides a constant temperature throughout its boiling, evaporating and condensing cycle.

The measuring device is a tall, insulated cylindrical chamber holding the sample. Inside the cylinder is a thermopile, made up of 20 individual thermocouples of iron and constantan. Minute amounts of heat measured result from growth of grains in the metal as its structure changes.

F-51 MUSTANG was considered a first class fighter plane in World II, but it is a far cry from today's F-94C Starfire, practically automatic with 1,200 lb of electronic gear. It illustrates the problem of . . .

. . . Military Designs: Are They Too Complex?

TO KEEP PACE with the change in materials of war—from piston engines to jets, from artillery to rockets, from piloted aircraft to guided missiles, and from conventional explosives to atomic warheads—U. S. designers have developed armaments that are replete with automatic mechanisms, loaded with safety devices, contain mazes of electronic gear and cost fabulous sums.

The big question is: Are our weapons becoming complex and loaded with gadgets beyond the point of diminishing returns?

▶ **Military View.** The Department of Defense says no. They claim that the speeded up pace of war forced present designs. They point out these influences:

World War II developments like radar, electronic computing devices and automatic control theory opened new vistas for military designers.

Operational requirements of present day combat demand a new degree of control, of speeds, and ranges; demands beyond the capabilities of a human operator or simple devices.

According to the semi-official *Army-Navy-Air Force Journal,* the U. S. should strive for top quality, even at the expense of maximum production. The paper puts military opinion this way: to freeze designs is to freeze progress; and any attempt to discourage costly gadgets and gimmicks would endanger lives on the battlefield.

▶ **In Opposition.** Critics, on the other hand, like Bernard Baruch and Senator Lyndon Johnson charge that excesses of gadgetry are "killing our boys with kindness". They urge not only more weapons immediately, but simpler weapons in design and construction. They also claim that we are paying far more for what we get than it's worth.

Proponents of simple weapons point to history to substantiate their theories. Since the Civil War, the U. S. has won military victories by out-producing the enemy after the war started. Victory came from the quality-quantity outpouring of industrial arsenals rather than by pure maneuver on the battlefield.

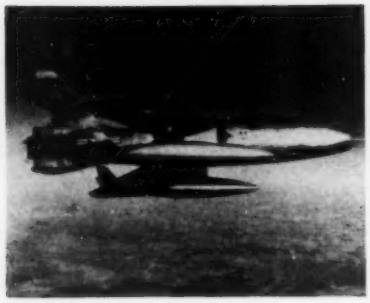
The design problem was simple. The U.S. developed a reasonably good weapon, not the best in the world, and then produced far more than the enemy could.

Today the Pentagon is attacking the design problem in a different way. As a basic fundamental they stress this: nothing is more valuable than the life of an American Soldier, and anything done to protect that life is worth the cost and effort.

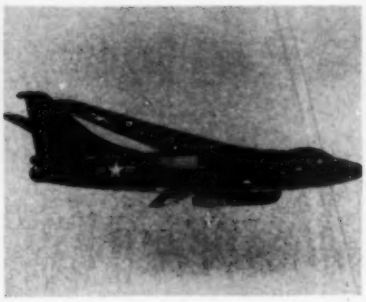
Therefore, they are demanding weapons that are the best in quality and performance. They ask designers to develop weapons, and any gadgets to go with them, to make them the best in the world.

This sometimes results in equipment that is loaded with safety devices, heavy armor, primary, secondary and even more systems of control and electrical circuits. Such designs frequently mean a loss in final performance and quality, the very things declared essential.

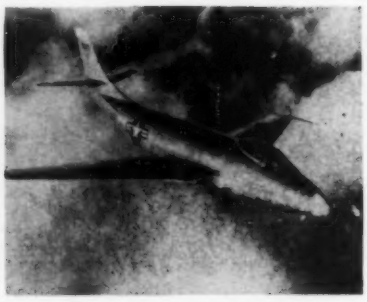
▶ **Russian Designs.** Design analyses (*Product Engineering,* Nov., '51, p. 134, Feb. '51, p. 124, Aug. '52, p. 194,



REPUBLIC'S XF-91, interceptor fighter.



DOUGLAS XA3D for the U. S. Navy.



McDONNELL'S XF-88 Voodoo.

Experimental Aircraft Are Draining Men, Resources,

Oct. '52, p. 154) show that the Russians have a different concept of design. They develop weapons of war to last a limited number of combat hours; they make them uncomplicated; they use castings and stampings wherever possible instead of machined parts; their finishes and tolerances are rough unless function demands close tolerances and ground finishes; and they provide a minimum amount of protection and safety devices.

Overall, the Communists strive to turn out a weapon that is as simple as possible, as inexpensive as possible, and one that will accomplish only one function.

Aircraft Design

The airplane is the most costly single weapon bought today by the services, exclusive of large naval combat ships, so the U. S. aircraft design program has the severest critics. That portion in the hottest contention revolves about jet fighter aircraft. A comparison between the Russian MiG-15 and the F-86 Sabre illustrates the problem.

▶ **Compared with Russians.** Experts rate the MiG as a top example of simplicity—it carries little more than bare essentials for flight instruments and actuating mechanisms for gear and flaps. It uses aluminum fences to prohibit sliding airflow along the tapered wings, a development U. S. designers are just adopting. The MiG carries a poor electronic gunsight because the Russians have been unable to develop one that can compare with U. S. standards.

The F-86 is as complex as the MiG is simple. It's a considerably larger plane; estimates put its weight almost 4,000 lb heavier than the MiG, mostly because of heavier armor plate, armament, and electronic gear.

From a performance standpoint, the Air Force claims superiority over the Russians. In air-to-air combat, U. S. pilots shoot down about 11 MiG-15's for every F-86 lost. But they also credit better trained and more experienced pilots as well as a performance edge in aircraft.

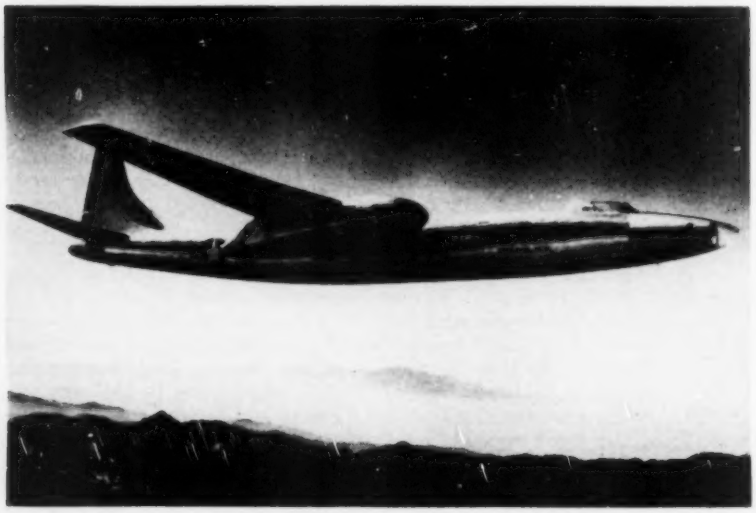
The argument reaches its peak on price. Experts guess the MiG costs $200,000; the Sabre $750,000-$1,000,000. The point is: Is the performance edge worth half a million dollars? Could it be obtained at a cheaper price by volume production of a different kind of airplane?

▶ **How costs mount.** As a rule of thumb, jet planes cost about $40 per pound. E. H. Heineman, Chief Engineer at Douglas Aircraft, figures that every pound of gear in the cockpit, requires an additional 10 lb distributed throughout the plane. That means that each pound of extra weight means an increase in cost of $440 per plane.

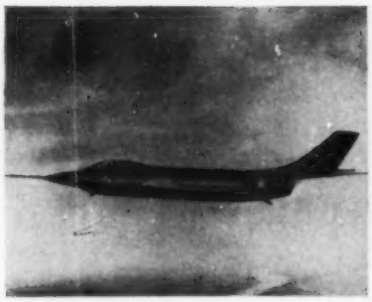
Typical expensive examples: wing deicers weighing about 300 lb increase the gross weight by an additional 3,000 lb and add $120,000 to the plane's cost. The auto pilot weighs about 110 lb, increases weight by 1,100 lb, and cost $44,000. Ejection seats weigh 100 lb, boost gross weight by 1,000 lb and add another $40,000 to the cost.

By eliminating just these three devices, designers could save 5,000 lb gross weight and almost $200,000. But the problem isn't that simple. Removing the ejection seat might prevent a pilot from bailing out of the jet in trouble since high speeds prevent him from getting out under his own power. And the Air Force has equally good reasons for having deicers and auto pilots too.

▶ **Expensive Extras.** Critics don't complain about that type of added mech-



CONSOLIDATED VULTEE'S XB-46, an Air Force experimental bomber.



McDONNELL'S XF3H-1 Demon.

DOUGLAS F4D Sky Radar(in prod.).

NORTHROP X-4 USAF Research plane.

Time and Money . . . Are so Many Necessary?

anism. The main blasts are directed at needless duplication of instruments and so-called luxury gadgets. These are typical:

• Automatic cockpit temperature controls. Even pilots agree that this feature and the addition of related temperature gages to an already cluttered instrument panel are extravagant in both weight, cost and maintenance. They point out that a pilot should be able to determine whether he is hot or cold; and since the proper temperature depends on his clothing, his physical condition, and the amount of exertion, he has to adjust the automatic control anyway.

• Radio Navigation Aids. Critics admit that these are most useful in peace time, but they doubt their value on combat aircraft in time of war. They point out that the enemy will not provide radio beacons over his territory. Too, the trend in tactics is for ground radar to direct fighters in front-line areas. They argue that navigational equipment adds more weight than it is worth to a combat fighter plane and the Air Force should screen this equipment more thoroughly before approving its use.

• Armament. The tendency on fighter craft is to install larger and larger guns. Too, designers are striving to reduce reloading time and increase gun life. This means heavier and heavier guns. Many experts feel that gun size and life should be pared down to save on weight, even if the guns last only 1,000 rounds. They point out that this might save the aircraft and it is easier to install new guns than to replace the entire airplane.

Most of the complaints about excess gadgetry involve a question of weight. This is because every added pound cuts performance and maneuverability. But logistics experts are also worried about the maintenance problems with these complicated gadgets. They figure it now takes too many men to keep a jet fighter in the air. And these men require on the average 25 weeks of training. Even now, the U. S. can not train enough mechanics to keep the required aircraft flying.

► **Design Trends.** Overall, the U. S. is moving towards even more complex aircraft. Pentagon sources claim that as plane speed increases, the need for more automatic controls becomes more urgent. They say that two jet airplanes emerging from clouds 1.5 miles apart and approaching head-on at a speed of 1,200 mph would crash before the pilots could see each other and react. So they have to rely on electronics to see for them, to aim, judge distance and fire guns.

In fighter plane design, the Air Force has shown a preference for the Delta wing configuration, capable of operating speeds at Mach 2 (twice the speed of sound). Pioneered in Germany and first fully developed by Consolidated Vultee Aircraft, the design is also being worked on by Lockheed, Republic, and North American.

This trend inherently forces more complex electronic devices but it may effect a saving in heavy armor and duplication of control and landing systems.

The Air Force is also experimenting with two different concepts of fighter plane design: one is a supersonic interceptor without extras. It's little more than wings, engine, pilot, and guns. The second fighter, currently favored, is the reverse; it's loaded with highly complex electronic controls and gadgets. The pilot only takes off and lands the aircraft.

Tank Design

Many industry people feel that a civilian or industry board should review design of military equipment.

GLENN L. MARTIN'S XB-48, an Air Force experimental bomber.

M-2 TANK with which the U. S. entered World War II was the result of arrested tank development. All riveted, it provided poor protection for its crew and limited firepower.

M-4 SHERMAN TANK was a mainstay of U. S. ground forces during World War II. An improvement over the M-2, it was still comparatively difficult to maneuver.

But Stop-and-Go Design Policy Impedes Tank

The medium tank program, which had such board, illustrates how a review board can operate to develop sound design.

When the Army asked industry to help in the development of a medium tank, the major contractors—Chrysler Corporation, General Motors, Ford Motor Company, and the American Locomotive Company—set up a committee composed of engineers from the participating companies. Meeting regularly once a week, they checked progress, reviewed designs before submitting them to the military, and tussled with coordination problems.

▶ **Simplifying Design.** As a starter, they scrutinized the initial specifications demanded by the Army's Ordnance Department. When they found a requirement that dictated, in their opinion, a complicated or extravagantly expensive mechanism, they asked the Army Ground Forces (who accept tank equipment for the Government) to justify the use.

If the explanation did not justify the expensive design, the committee ruled it out. In this way, they checked the use of complicated and expensive gadgets. And at the same time, the civilian designers got an intimate picture of what the tank had to do and how it was to be used.

Here are two examples of how this procedure worked.

1) The previous medium tank model, the M-47, had an automatic fire control system. Ordnance wanted one on the new tank, too. The civilian designers felt that such a system was too complicated, too expensive, and invited a difficult maintenance problem. They asked the Ground Forces why they needed it. The answer was that they didn't actually need an automatic system; all that combat troops required was some means of putting the tank guns into firing position almost instantly.

Designers solved the problem with an electrically powered turret, improved optical rangefinder, and manual firing that filled the performance bill, but was not too complicated, not too expensive, and required a minimum of maintenance.

2) There was, on the other hand, agitation to get rid of the auxiliary power plant, engine and generator. Engineers felt that the main power plant was more than adequate. But combat officers explained that the unit served many other functions and was essential.

It was needed to warm up the main engine in freezing weather; it supplied electricity to operate the turret when the tank was hiding and couldn't use the noisy main engines; it permitted quiet charging of the tank's batteries. As a result, the auxiliary generator and power plant stayed in the design.

This type of give-and-take, coupled with industry-government cooperation, produced the design of the M-48 medium tank, which many people consider the best tank of its size in the world.

In the M-48 there are no duplicate electric or hydraulic circuits. Instead, designers locate wiring and piping in protected positions, away from the sides of the vehicle.

▶ **Simplifying Tolerances.** The committee also tackled one other problem that complicates military design and production—standards and tolerances. Their approach: Whenever a contractor or sub-contractor encountered difficulty or extreme expense meeting a tolerance or finish, the committee reviewed the specification to see if it was absolutely necessary. If not, the tolerance was corrected. In this way they were able to eliminate considerable over-design.

Since the military also turned over responsibility for building a foundation for extensive production if that should be needed, the committee considered production feasibility in their design. One example illustrates this.

The M-48 is the first tank to have an all-cast hull. Much has been made of the ballistic properties of this design—it permits deflection of shell hits. But not so well known is the production advantage involved. The cast hull eliminates a welding operation that used 1,200 lb of hard-to-get nickel rod and hundreds of man-hours of expensive labor for each tank.

Designers admit that the M-48 is

M-46 PATTON I climaxed World War II tank development. This was one of the first U. S. designs produced by evolution—from the M-4 to the M-26 to the M-46.

M-48 is the newest medium tank. Developed with industry-government cooperation it is considered the best tank of its size in the world, affording good protection and firepower.

Development and Raises Costs

still an expensive tank, costing about $200,000 each, and it has too many complicated mechanisms. They claim that it's successsor, currently on drawing boards, will cost less, perform better, and be simpler in design.

However, tankmakers claim that the M-48 costs no more than the World War II M-4 if inflationary costs of material and labor are ignored.

Now that the Army Ground Forces have accepted the M-48, the same contractors are using their design organization to develop a heavy tank. Observers expect that the U. S. will unveil a new heavy tank sometime this summer or in the early fall.

▶ **For the Future.** Industry engineers who worked on the M-48 make these recommendations for future tank design:

1) They insist that the U. S. must maintain a constant program for developing tanks. They blame the high cost of the M-48 on the U. S.'s stop-and-go policy of tank development. When designers started on the M-48, they had to begin from scratch.

Here's what had happened: After World War I, the U. S. did not build or develop a tank until the 1930's when the Army built one or two tanks. They then dropped the program until just before the last war. During the war, development, once started, moved smoothly.

Starting with the M-2 riveted model, Ordnance advanced to the M-4 Sherman, and then to the M-26 Pershing. But after World War II, tank development was forgotten until the Korean fighting started. Ordnance first tried to improve the Pershing and developed the M-47; but when industry entered the picture, it was decided to develop a brand new tank.

▶ **Need Periodic Redesign.** Chester Utz, chief of tank design at the Chrysler Corporation, says the tank must be redesigned completely every five years. He explains that new developments in materials, metallurgy, electronics and engineering, make a tank obsolete and expensive after that period of time.

As proof, industry engineers have already been able to make design changes on the M-48 that will save money and maintenance time. They point out that gradual evolution is the way to develop economical tanks.

2) Engineer executives urge a better distribution of technical information. They credit the success of the M-48 program, in part, to the rapid exchange in their own group. But they add that this is not enough. They found that other government agencies had made developments that could have been used in the M-48. But because they were classified, nobody knew about them until it was too late.

Electronics

No other country in the world uses electronics to the same extent as the U. S. The reason: most other nations lack a well-developed electronics industry and the funds to spend.

Electronic gear is the most costly equipment developed to aid armaments. The electronics on a modern fighter plane, as a typical example, cost three times what a complete World War II fighter cost.

Engineers who oppose such extensive use of this gear offer two other objections in addition to cost: unreliability, and maintenance.

▶ **Unreliability.** There's strong support for this argument. Vacuum tube manufacturers admit that they cannot predict how long a tube will last. They can determine an average life, but laboratory tests rarely duplicate field data because conditions of temperature and shock are not similar.

In present bomber aircraft, with gear containing 1,200 tubes, statistic analysis predicts that one vacuum tube will fail every hour. As the number of tubes increases, the chance of a tube failure becomes more likely.

The simplification proponents point out that if a vacuum tube in a critical gear fails during combat, the advantages of the complex automatic equipment are lost. And even more important, it could kill the soldier it was designed to protect or assist.

Electronics is still a relatively young field. Many developments barely get out of the laboratory before they are superseded by newer circuits.

Military men are aware of this un-

trustworthiness of electronic tubes. They've tried to overcome it with more reliable tubes, and more reliable circuits. But the problem still remains.

A recent National Bureau of Standards development, the tube failure prediction unit, may help. Too, transistors, when they reach a stage of successful application, might solve the problem.

The answer, critics claim, is to keep electronic gear in experimental weapons until a degree of reliability has been reached, and the field has tended to stabilize. They point out that the military would never accept mechanical or hydraulic systems with the vagaries of electronic gear.

► **Electronic Maintenance.** From a maintenance standpoint, electronics offer a serious headache. The Navy estimates that it spends $27,000 to train a single enlisted electronics specialist. And this year the Navy requested over $23,000,000 for training aids to help turn out guided missile experts, electronic technicians and pilots.

The Defense Department says they use electronics for two reasons: 1) to see where the human eye cannot reach, and 2) to replace manpower. But critics point to the army of technicians needed to keep the electronic gear in service as no manpower saving.

To stimulate industry's simplification of electronics, the Defense Department has inaugurated an incentive type of contract. They plan to give a contractor a larger rate of profit if he is able to design and perfect gear, simpler than its predecessor, that will perform its assigned task.

Design Recommendations

Veteran design engineers view some portions of the U. S. armament program with concern. Here are some typical recommendations to simplify equipment and reduce its cost:

- Use basic science to solve problems instead of building up complex gadgets. Veterans attribute much of the complexity of equipment to a failure to make a basic analysis of the function it is to perform. Instead, engineers are working backwards.
- Improve the distribution of technical information. Most common complaint heard about the armament program is the excessive security classifications imposed by the military services. This not only slows up development, but increases costs since security measures are expensive. Some industry observers estimate that as much as 60 percent of the material classified, should not have a secrecy or classification label.
- Improve coordination of design and development in a field. Experts criticize the aircraft program particularly because every major company is working on their own aircraft design. As a result, the Air Force has a dozen experimental planes with accompanying waste of money, materials and personnel. They point to the tank program where all contractors cooperated to develop one outstanding basic design.

These men recognize that a different problem exists with aircraft. They do not propose that the services be limited to a single design. But they do think the current number of experimental aircraft is excessive.

One encouraging note: the recent program inaugurated by the Aircraft Industries Association. In this, AIA assigns specific basic research projects to various companies. Results are then disseminated to all manufacturers to avoid duplication.

- Establish an out-of-military Board of Review to pass on weapon specifications. Many industry people feel that military specifications demand far too complicated solutions to combat problems. They feel that an impartial board could temper these without bias or prejudice and keep weapons practical and reasonably priced.
- Design parts with low-cost production in mind. Criticism has been aimed at many structures and components because their manufacture requires complicated and expensive procedures. As a good example, critics point to World War II aircraft production in Germany. At the height of Allied bombings, German production continued to rise. Observers credit the heavy forging equipment and presses that the Germans used more than industrial dispersion. Because the ME-109 was a model of aircraft simplicity, they were virtually stamped out of aluminum without loss of time-consuming fabricating and riveting processes.

Another King Size Extrusion Press

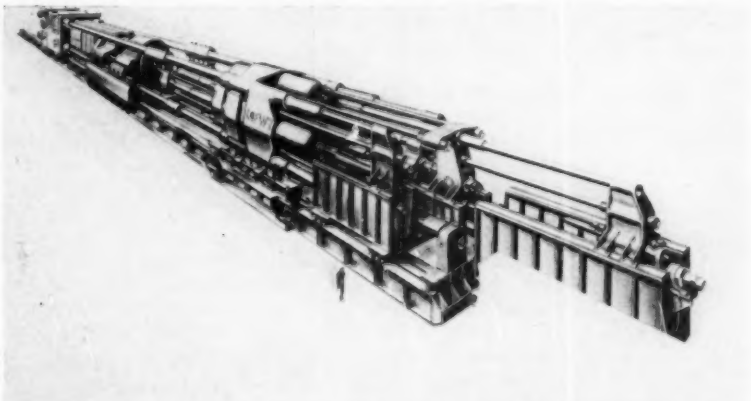
AN EXTRUSION PRESS of 20,000 ton capacity will be installed in the Lafayette, Indiana, plant of the Aluminum Company of America to supplement the 14,000 ton unit now under construction for fabrication of large structural shapes.

Under lease arrangement with the U. S. Air Force, the press is another part of the heavy press program for essential military production of wide ribbed shapes for integrally stiffened wing panels and heavy shapes for spar caps. Present planning is to use the press for peacetime production of wide, thin shapes, and large size pipe for the chemical industries.

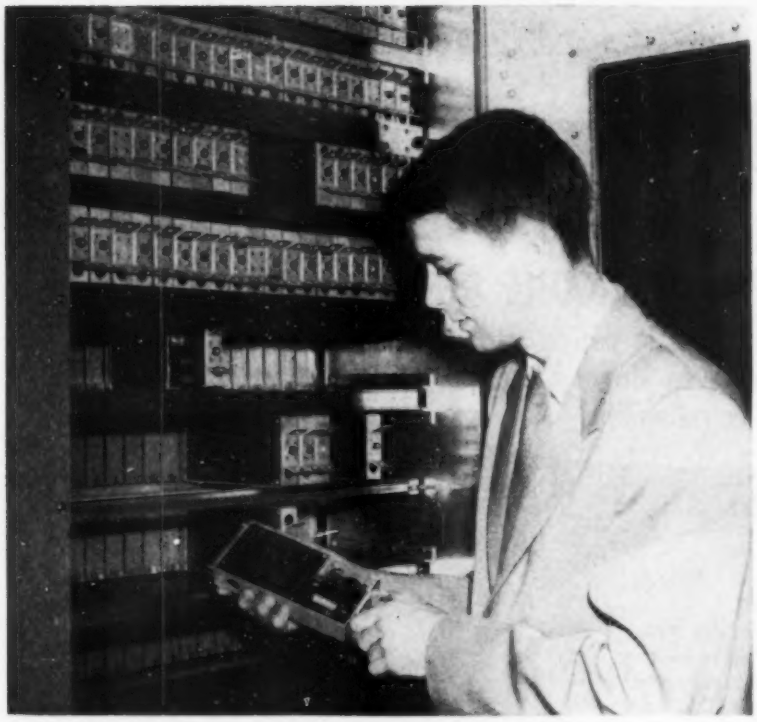
Scheduled for completion by mid 1954, the new press will extrude shapes weighing up to 4,500 lb from ingots of 8 to 41 in. dia and up to 8 ft in length.

To relieve internal strains and to straighten the shapes after extrusion, Alcoa will install a 3,000,000 lb stretcher. It will straighten shapes up to 60 sq in. in cross-sectional area in one of the strongest aircraft alloys, 75S.

Maximum length for heat-treated shapes is 90 ft set by existing heat-treating equipment.



Perspective of 20 ton Hydraulic Extrusion Press being built by ALCOA for Air Force. 10 and 20 ton capacity in two stages. Equipped with four 206 in-stroke main cylinders; moving saw and shear for butt end separation; hydraulic operating billet loading device. Maximum operating pressure of 4,500 psi. Full rating is 15 cycles per hour.



PLUGGING a "standardized circuitry package" into new Defense Dept. electronic computer at National Bureau of Standards. Packages supply about 90 percent of total circuitry requirements, exclusive of memory units.

NBS Designs "Building Block" Computer

AN ADVANCED ELECTRONIC COMPUTER now under development for the Department of Defense will utilize standardized circuitry packages that can be adapted to other digital computers to reduce manufacturing cost and simplify maintenance, according to scientists at the National Bureau of Standards. By the proper interconnection of a sufficient number of the new NBS units, most of the circuitry of large complex computers can be constructed.

Each circuit "package" has a large number of connections brought out to connector pins, making different uses possible. A test jack at the top of each package helps locate defective units, and as soon as a trouble-causing package is located a trouble-free one can be inserted in its place.

The basic NBS package consists of an amplifier tube, a pulse transformer and a number of germanium diodes. The total number of diodes required per package may be as high as 38 (some are in parallel), most of them for signal input. Since not all prospective applications will require so many diodes, four slightly altered versions of the NBS unit are provided, embodying different numbers of diodes. The four versions which are sufficiently similar to permit mass production are already being made for the Bureau by a private manufacturer.

A second type of package, identical in size to that containing the tube and diodes, houses delay lines for interconnection between stages. Both types are designed for durability, mass production, and quick testing and servicing by easily trained personnel. Etched circuitry and dip-soldering help make construction simple and foolproof.

Plans for the new NBS computer call for some 800 packages, plugged into 10 chassis holding 80 packages each. The chassis are on racks measuring about 7 ft high by 3 ft wide. Each rack holds four chassis. A handle at the end of each package facilitates insertion and withdrawal. Heavy guide pins assure correct insertion and protect the 60 connector pins from accidental damage in handling. Many of the components in the package are connected to separate pins and have no connection with other components when the package is unplugged. This has two advantages: (1) it permits flexibility in external connection, and (2) permits testing the unplugged package for faulty components without improvised circuit paths. The test jack at the top of each unit permits checking of output signals by means of an oscilloscope.

Defective components within individual packages are located with a special test unit. The package is plugged into the test equipment and a selector switch is rotated to obtain checks on each component. Trouble free packages are tested periodically as a routine preventive-maintenance measure; components whose characteristics have drifted beyond acceptable tolerances are replaced. These test procedures, requiring specialized test equipment, are applicable to the standardized-package system.

Prestraining Effects Copper Properties

PRESTRAINING directly effects the room temperature tensile properties, hardness, and microstructure of high purity copper, according to results of a recent investigation conducted by the thermal metallurgy laboratory of National Bureau of Standards. Also, test studies indicate that tensile properties of metals depend only upon the instantaneous strain state of the metal, and are generally independent of the way used to obtain the state.

Tests were made on oxygen-free high-conductivity (OFHC) copper initially an annealed, as cold-drawn different amounts, and as pre-strained in creep at 110 F, 250 F and 300 F.

Results concluded from the test are: (1) Cold-drawing at a relatively fast strain rate generally results in increased strength and hardness, but decreased ductility. (2) Prestraining at high temperature or low strain rate generally results in reduced strength, hardness and ductility. (3) Specimens with larger grain sizes show lower yield strength and hardness values. (4) Grain size has little effect on tensile strength or ductility.

HELI-COIL CORPORATION announces the selection of six judges for their Student Design Award Contest (*Product Engineering*, Dec. 1952, p. 195): industrial designers A. Baker Barnhart and Francesco Collura; Austin A. Church, NYU Professor of Mechanical Engineering; Karl H. Tietjen, consulting engineer; George F. Nordenholt, editor *Product Engineering;* and Colin Carmichael, editor *Machine Design.*

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Dimensional Allowance Charts for Helical Wire Springs

VICTOR TATARINOV
Pilsen, Czechoslovakia

WHEN DESIGNING helical springs, the diameter of wire required to satisfy the load and deflection characteristics often falls between standard gages available commercially. A normal procedure in such cases is to use the next larger standard size. However, if it is necessary to evaluate the effects of the variation between the calculated and standard wire diameter, it may be necessary to repeat a considerable number of calculations.

This procedure can be simplified by the nomographs on the pages that follow. These charts which illustrate the effects of different allowances on the spring loads and deflections were constructed on the basis of the classical spring deflection formula:

$$\frac{f_o}{P_o} = \frac{8\,(D-d)^3 n}{Gd^4} \quad (1)$$

where

P_o = working load, lb
f_o = deflection produced by P_o, in.
d = wire diameter, in.
D = outside coil diameter, in.
G = torsional modulus of the spring material, psi
n = number of active coils

Letting the variation or allowance in diameter d be represented by $\pm a$, Eq (1) can be written as follows:

$$\frac{f}{P} = \frac{8\,(D-d\pm a)^3 n}{G\,(d\pm a)^4} \quad (2)$$

where

f and P represent the new values of deflection and load, respectively.

Dividing Eq (1) by (2), selecting $f = f_o$, and assuming $(D\text{-}d \pm a)$ is approximately equal to $(D\text{-}d)$,

$$\frac{P}{P_o} = \frac{(d\pm a)^4}{d^4} \quad (3)$$

Letting $P/P_o = x$,

$$\pm a = d\,(\sqrt[4]{x} - 1) \quad (4)$$

In a similar manner, if $P = P_o$, the ratio f/f_o, which is designated y, is expressed by

$$y = 1/x \quad (5)$$

The curves of Fig. 1 are based on Eq (4) and (5). The left hand curve is plotted for negative values of a, while the right hand curve is used when a is positive. The value x and y are expressed in percentages. Negative values must be subtracted from 1.00 as illustrated in the sample problem below.

Given: $D = 4$ in., $P_o = 110$ lb, $f_o = 2.0$ in., and $d = 0.157$ in. The nearest standard wire size is 0.162 in.

Solution: $a = 0.162 - 0.157 = +0.005$. Thus the right hand curve is used. The intersection of the heavy dotted lines on Fig. 1 show the load variation x to be 13.7 percent. Thus $P = 1.137\ P_o = 125$ lb.

The deflection y is —12 percent from the curve. That is, if $P = P_o$,

$$f = \frac{f_o}{1.137} = \frac{2}{1.137} = 1.76 \text{ in.}$$

Thus, $y = f/2 = 0.88$ or —12 percent, which checks the value from the curve.

The graphs in Fig. 2 establish a relationship between values of $(D\text{-}d)$, x, y, and the outside coil diameter allowance which is designated by $\pm b$. The fundamental formula incorporating this allowance can be written as follows:

$$\frac{f}{P} = \frac{8\,(D-d\pm b)^3 n}{Gd^4}$$

Dividing Eq (1) by (6) and selecting $f = f_o$,

$$x = \frac{(D-d)^3}{(D-d\pm b)^3} \quad (7)$$

Thus, $$\pm b = \frac{(D-d)\,(1-\sqrt[3]{x})}{\sqrt[3]{x}} \quad (8)$$

Eq (8) is the basis of the two graphs in Fig. 2. As before, the left hand one is used for minus allowances and the right hand one for positive values. Example 2. Using values of the previous example and an allowance for outside diameter of spring, $b = \pm 0.1$ in., $D\text{-}d = 4.0 - 0.157 = 3.843$ in. The intersection of the line designating $b = \pm 0.1$ and that designating $D\text{-}d = 3.843$, indicates a value of load variation equal to —7.4 percent. Thus $x = 1.0 - 0.074 = 0.926$. $P = 0.926 \times 110 = 102$ lb,

$$y = \frac{1}{x} = 1.08, \text{ i.e., } +8 \text{ percent.}$$

Also

$$f = \frac{f_o}{0.926} = 2.16 \text{ in.}$$

The charts in Figs. 1 and 2 enable the spring designer to check the combined effect of wire size and spring diameter allowances. Considering the above numerical examples indicating load percentage additions equal to +13.7 and —7.4 percent, the combined effect will then become $+13.7 - 7.4 = +6.3$ percent. The actual load on spring $P = 110 \times 1.063 = 116.9$ lb. With $P = P_o$,

$$f = \frac{2}{1.063} = 1.88 \text{ in.}$$

These graphs can also be useful in determining the effects of dimensional tolerances applied to the coil and wire diameters on the load and deflection characteristics. In practice, the allowable load and deflection deviation cannot be higher than 10 percent for springs up to $\frac{1}{2}$ in. in dia, 8 percent for 2 in. springs, and 5 percent for larger diameters.

(Continued on page 209)

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Dimensional Allowance Charts for Helical Wire Springs (continued)

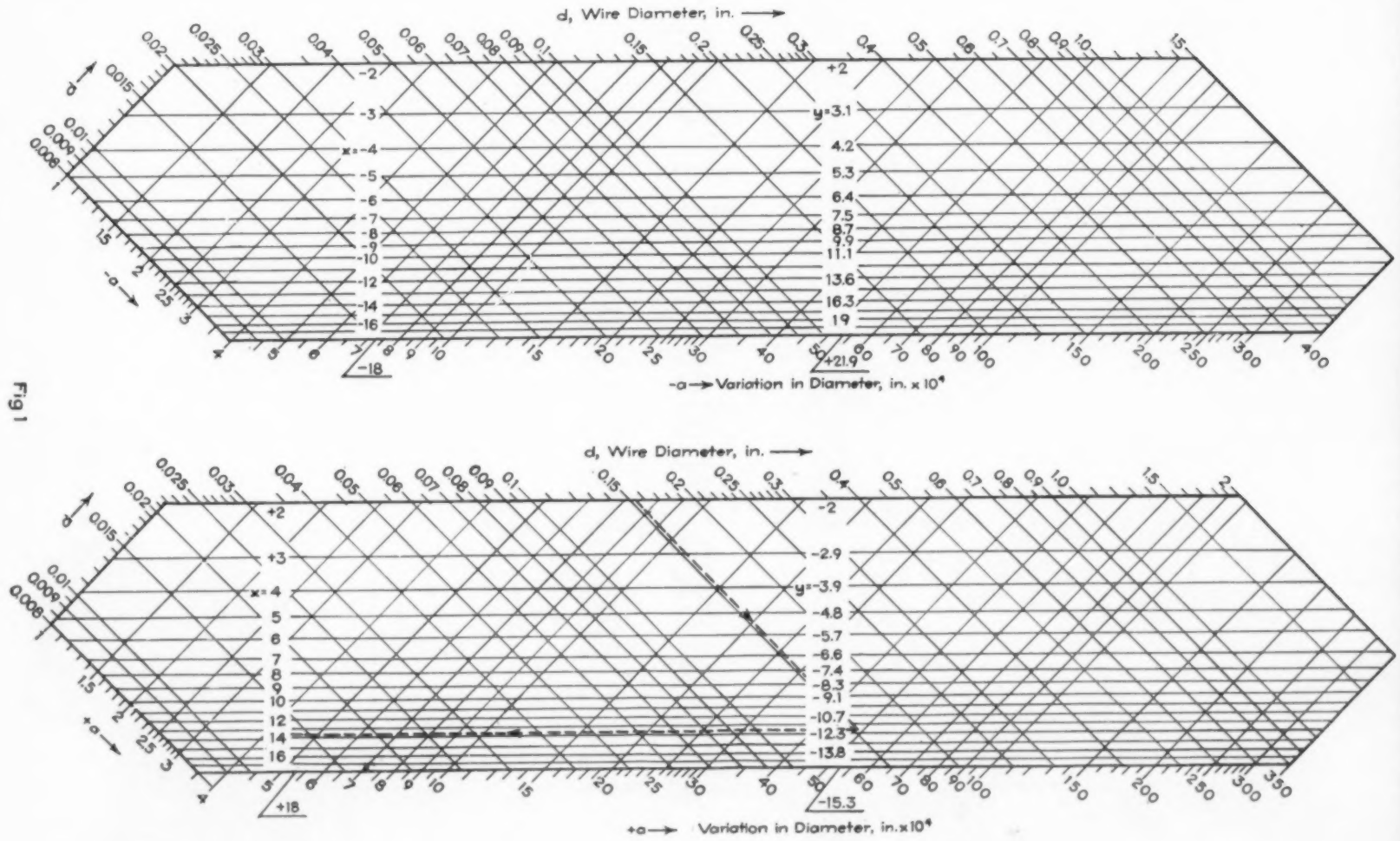
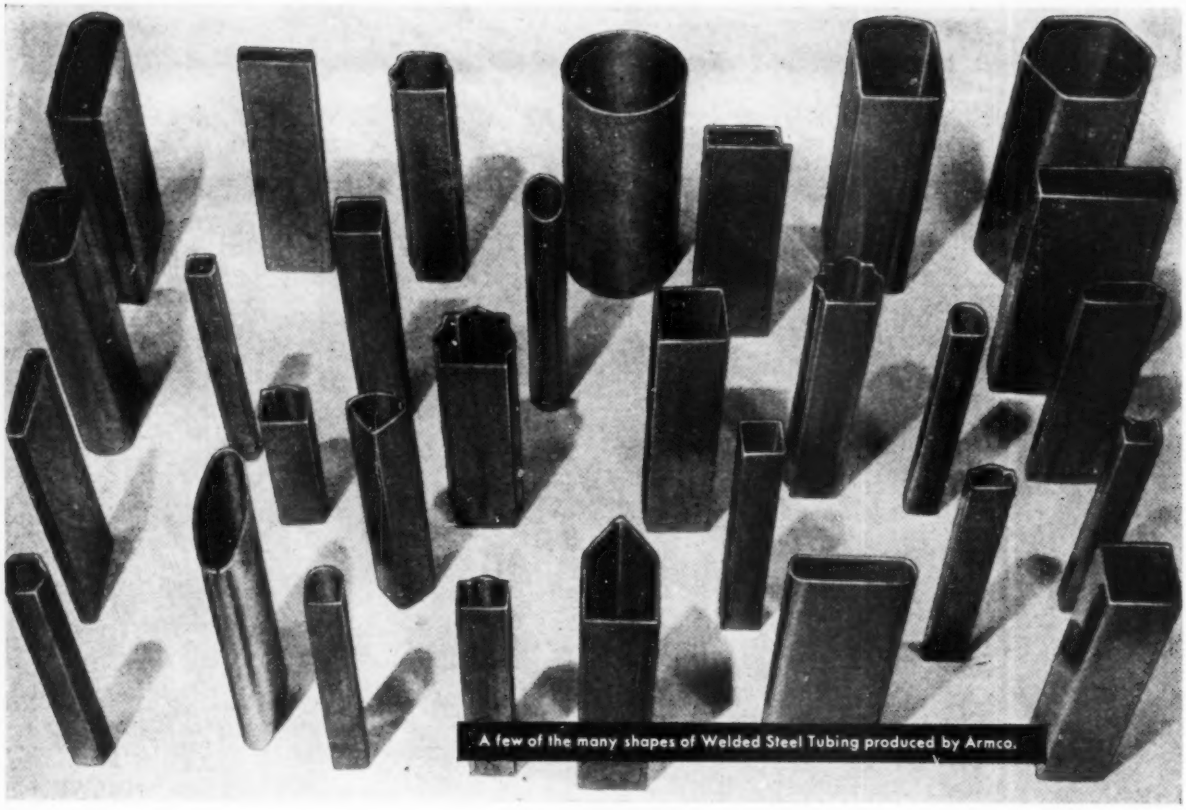


Fig 1

(Continued on page 211)



A few of the many shapes of Welded Steel Tubing produced by Armco.

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Dimensional Allowance Charts for Helical Wire Springs (continued)

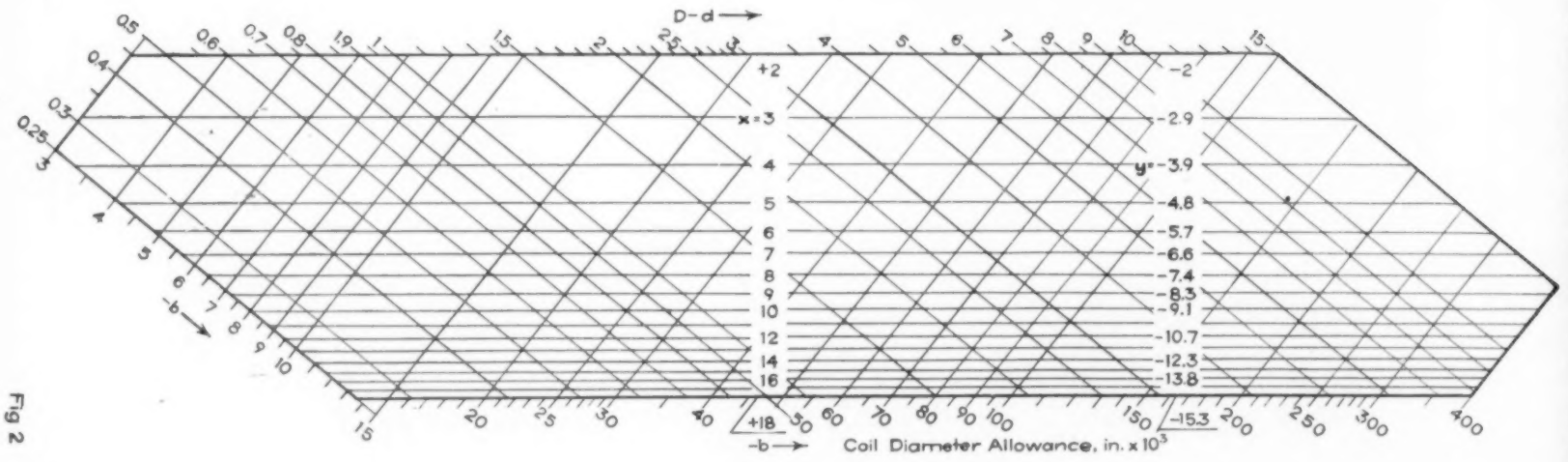
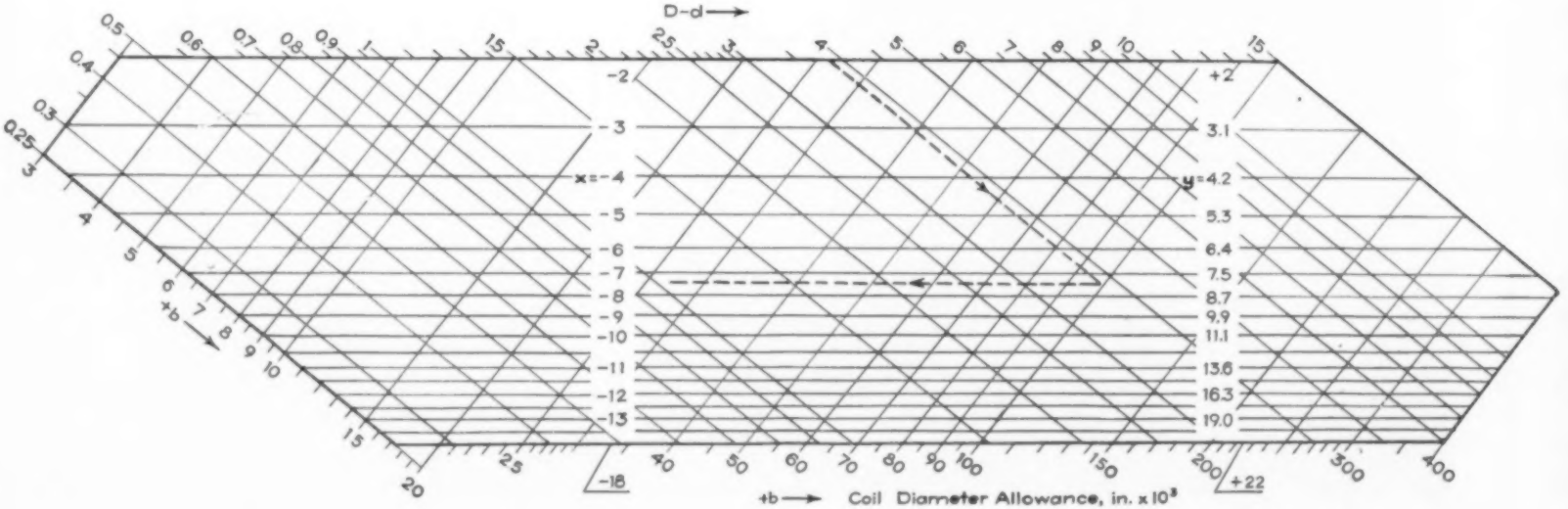
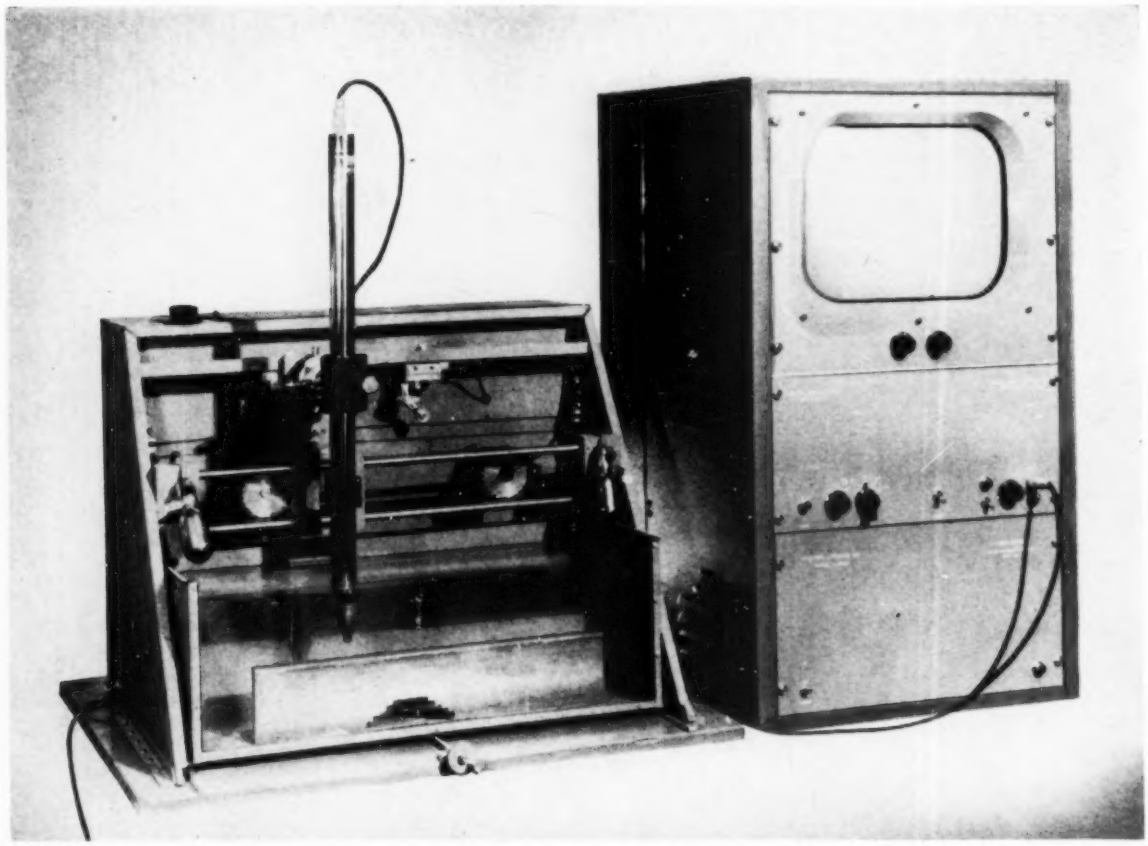


Fig 2



NEW COMPONENTS-



CROSS-SECTION VIEWS of the interior of a metal specimen are shown on a 16 inch television type cathode ray tube, with the flaws showing their length and depth below the surface. The pyramid cutout section of the metal specimen is shown on the screen.

Ultrasonic Inspection of Sub-Surface Defects

In the contact-scanning method used in ultrasonic inspection of large metal objects, it is usually necessary to machine or grind the surface of the metal before it can be inspected. With a new system using the B-scan technique, the metal is immersed in rust-inhibited water, and the crystal scans the metal without being in contact with the metal. The several inches of water between the crystal and the metal makes it possible for the crystal motion to be mechanized without concern for the small contour changes in the metal being inspected. Also, the B-scan unit should be operated in conjunction with an echo type flaw detector to give the echo height standardization not readily obtained from a television type display.

The use of the mechanized crystal scanning allows electronic circuits to calculate the position of the crystal relative to the object being inspected. Once this position is known in electrical terms, the data can be fed to a television type display tube. Changes in the horizontal position of the crystal cause similar changes in the horizontal position of the beam in the cathode ray television type tube. The vertical position of the cathode ray tube beam is determined by the elapsed time between sending the ultrasound pulse and the received echoes from the metal object being inspected.

Ultrasound frequencies of from five to twenty-five megacycles are used. The higher frequencies give the best resolving power, because they will permit the distinguishing of flaws that lie close to the surface. Some metals such as low carbon steels require that the frequency be kept as low as five megacycles. This is due to the high absorption of ultrasound of higher frequencies. Aluminum alloys that have been rolled, extruded, or forged can be inspected at 25 megacycles.

The amplifying circuits that convert the minute ultrasound echoes into the large signals needed to brighten the television screen must have unusual properties. These amplifiers need simultaneous high gain, broad band, and

rapid recovery from large signals. Ten stages of these amplifiers are cascaded to obtain the desired overall gain.

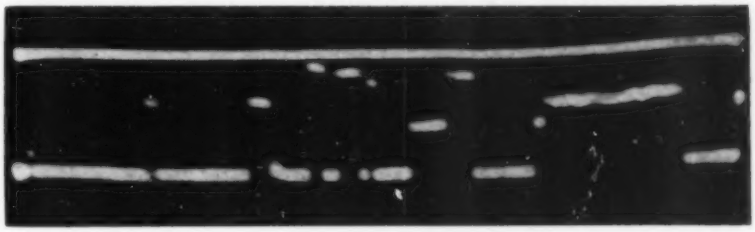
The B-scan system, consisting of the wide band converter and the ultrasonic presentation unit, permit inspection of the specimens at a high rate of speed. Image persistance on a new phosphor screen shows the small indications, although the transverse scanning crystal may be moving rapidly.

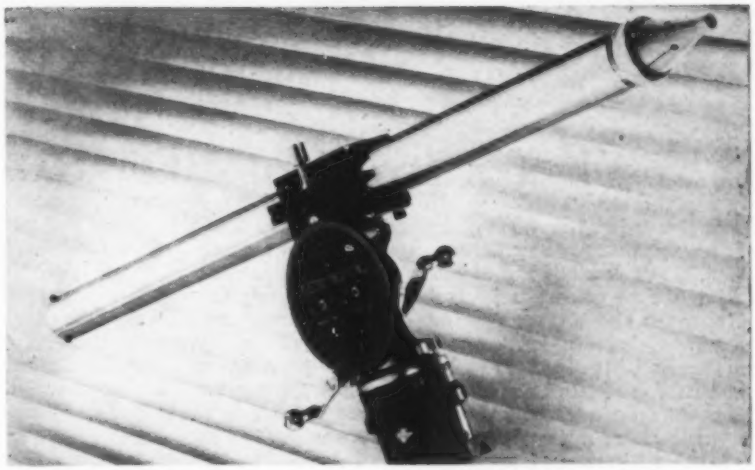
Variable magnification, controlled by the operator, will permit the sample being inspected to appear several times greater, or long samples to be compressed to fit the viewing screen. Data concerning the horizontal position of the trace on the viewing tube is obtained from a potentiometer turned by the scanning mechanism.

Cross-section views of the interior metal give much the same information as is obtained from an etched slice taken from the metal, but the features of the B-scan method are that looking at a cross-section is non-destructive, and requires about one second per slice.

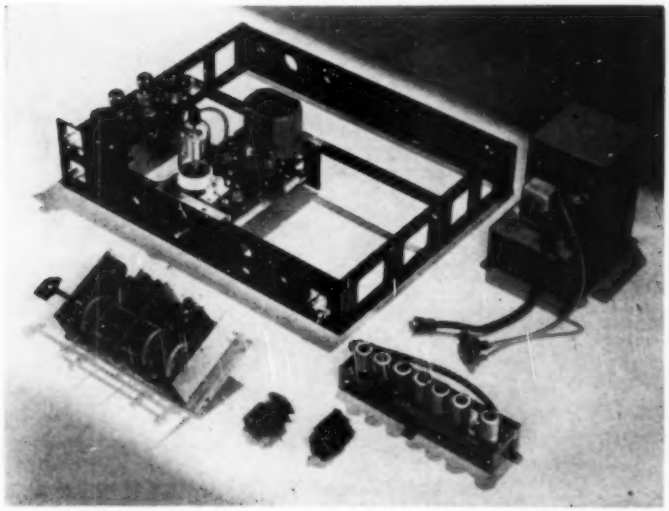
If it is necessary to present more than a cross-section view of the interior of the metal, the B-scan instrument can be fed auxiliary data which will permit a plan view and cross-sections of cylindrical objects to be drawn.

Electrocircuits, Inc.,
401 *E. Green St., Pasadena* 1, *Calif.*

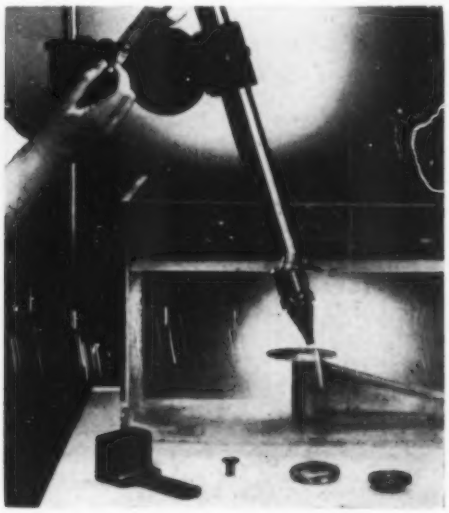




AN IMAGE OBTAINED ON THE TELEVISION SCREEN of laminations inside a ⅛ inch thick aluminum plate is shown at top. The upper-most and lower lines are the top and bottom surfaces of the plate. The short internal lines are the defects. The defects cast acoustic shadows on the bottom surface. In the illustration below is shown the ultrasonic search unit and its manipulator for immersed inspection.

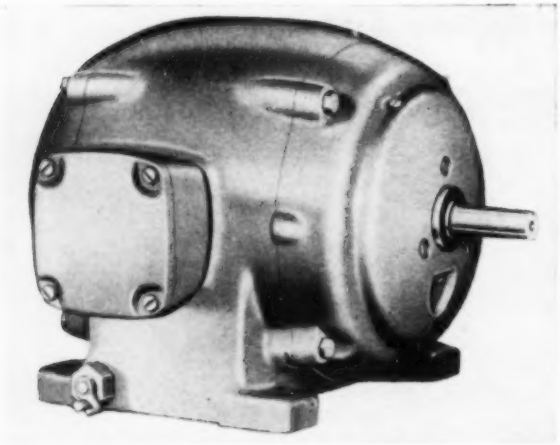


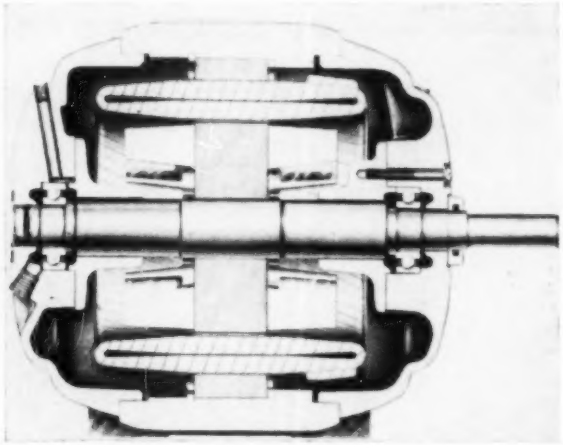
CHASSIS of the ultrasonic inspection units are made up of the various sub-assemblies shown. This gives high circuit density, as a given sub-assembly can be removed for service. Uses frequencies from 5 to 25 megacycles.



CRYSTAL SEARCH UNIT in operating position on a shear mode inspection. Either shear or longitudinal mode ultrasound can be induced in the metal.

CONTINUED ON PAGE 214





Totally Enclosed Motor For Hazardous Locations

Designated as type SS, and designed for services where dampness, dust, fire hazards, and corrosive fumes are common, a new totally enclosed motor is self-cooling, eliminating the use of an exterior fan and heat dissipating fins. The motor also has a slinger to protect the output shaft bearing against dirt and water. This motor, also available in type SES, has been approved for explosion-proof service in hazardous locations by the Underwriters' Laboratories, Inc. Any moist condensation that sometimes occurs in totally enclosed motors is caused by the "breathing" of the motor, and is released through a special drain plug.

These new motors are available in a range from $\frac{1}{3}$ to 2 hp (also fan-cooled to 75 hp) and will be produced in larger ratings. According to N.E.M.A. standards, types SS and SES also have such features as: modern exterior design; sealed terminal chamber; normalized castings; asbestos-protected windings; solid centricast rotor; and special lubri-flush bearings which have an extra large lubricant chamber and provision for forcing the grease through the bearing for a complete purge of the old grease.

U. S. Electrical Motors Inc., Box 2058, *Los Angeles* 54, *Calif.*

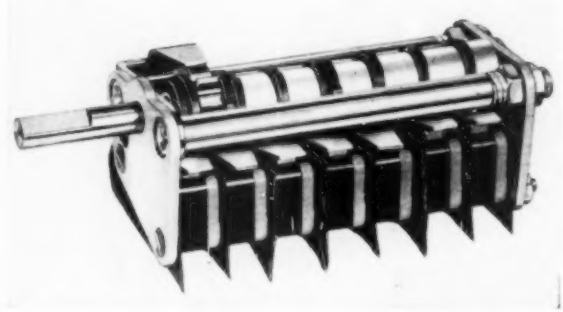
Small Size Multiple Rotary Switch Assemblies

Designed especially for aircraft use but adaptable to a wide variety of either a-c or d-c switching applications, a new series of small size multiple rotary switches assemblies has such applications as: lighting control; aircraft landing gear indicators; x-ray and electronic equipment; and aircraft electric windshield wipers.

One of the series is a ganged assembly of seven V3 type basic switches made by this company with single-pole, double-throw contact arrangement. Each basic switch measures $\frac{13}{32}$ x $\frac{5}{8}$ x $1\frac{3}{32}$ inches, and the entire assembly measures $1\frac{1}{2}$ x $1\frac{5}{8}$ x $4\frac{3}{4}$ inches.

In its initial use as an aircraft cockpit lighting control of multiple circuits, this assembly has been found to have good resistance to vibration. The pivoted cam followers maintain their adjustment, and the detent mechanism assures a positive feel of each position. Cam combinations can be used to give any desired sequency of circuit control or switching arrangement.

The d-c rating of the switch, known as model 7AS71 assembly for inductive and heater load is: 30 volt, 10 amperes at sea level; 30 volt, 6 amperes at 50,000 feet altitude. The a-c rating for inductive and heater load is: 125 or 250 volts—10 amperes. Current ratings are based on a maximum permissible temperature rise of 65 C.



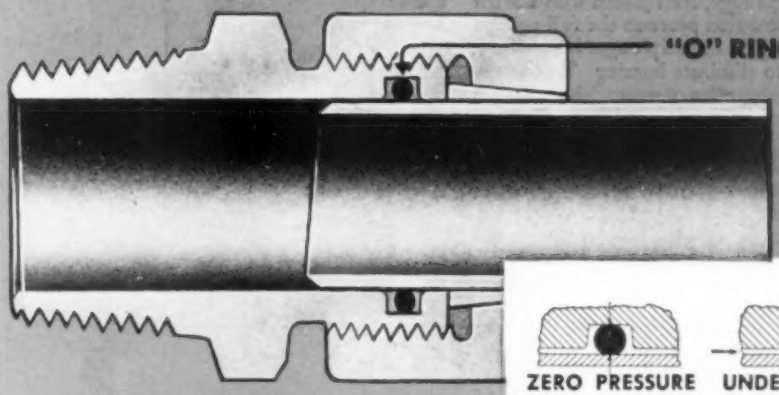
There are other variations of the 7AS71 assembly available in from three to eight gang assemblies of V3 type single-pole double-throw basic switches and from two to eight switching positions at 45 degrees angular rotation between the positions.

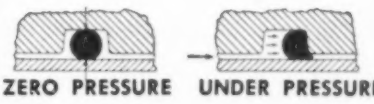
Another type of aircraft switch assembly made by this company is available with from one to 10 double-throw switching elements, all operated by a single lever.

Micro Switch, Freeport, Ill.

CONTINUED ON PAGE 216

A PRECISION "O" RING
makes this coupling *leak-proof* and easy to assemble!





Zero Pressure: The initial diametral squeeze seals at zero pressure. *Under Pressure:* The "O" Ring is forced to the edge of the groove—the higher the pressure, the tighter the seal!

The *Lenz Company* of Dayton, Ohio employs a *Precision* "O" Ring in this tube coupling to eliminate need for flaring, threading, welding and soldering. Nut fits loosely on tube for quick, easy assembly. Efficient sealing does not depend on tightness of the nut. A *Precision* "O" Ring makes the seal—and the higher the pressure, the tighter the seal.

Everyone is finding *Precision* "O" Rings the best answer to many sealing problems . . . and they are finding, too, that *Precision* leads the field in engineering help and proper deliveries to keep production lines going. Let us work with you. Send for our "O" Ring Handbook and let us have your inquiries.

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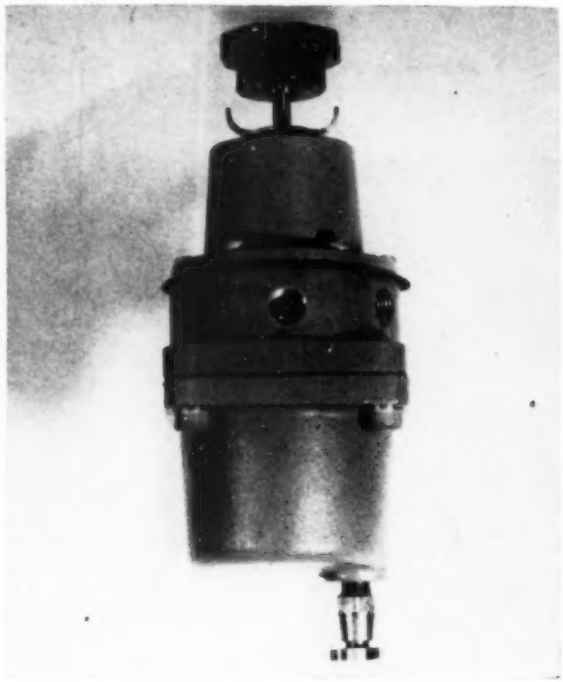
Combination Air Pressure Regulator And Filter

Line pressures up to 150 psi can be reduced and maintained at any regulated output pressure from zero to 35 psi without appreciable drift or air consumption in a new combination pressure regulator and filter. The new unit has an end cap that houses the filter and forms the dripwell, and has a connection for mounting a pressure gage.

Functionally, the circuit of the new regulator is similar to an earlier model, both operating on the pneumatic-balance principle. In the new unit the diaphragm chamber is isolated from the output passage, then joined with a small feedback passage. The construction prevents the full volume of output air from impinging on the diaphragm before leaving the regulator, helping to eliminate buzzing. The design also permits guidance of the pilot stem to give positive seating against the supply and exhaust ports, minimizing air consumption.

The regulator can be manually set to control output air pressure at any value from 0-35 psi. When the force of the spring on one side of the diaphragm is balanced by the pressure on the other side, the exhaust port is closed and the supply port is open wide enough to maintain the regulated pressure at the selected value. A change in knob setting increases or decreases the force of the spring, causing unbalance. The supply or exhaust port then opens to change the regulated pressure so that it again balances the spring force. At this point the exhaust port again closes and the supply port takes the proper position to maintain balance. Also, when a change in supply pressure or in flow demand causes unbalance, the regulator acts to return the regulated pressure to the set value.

The maximum dimensions of the new integral unit are approximately 9 in. and 3⅛ inches. It has three main sections: (1) a bonnet which houses the adjusting stem and loading spring; (2) a center ring containing the pilot stem and the port seats, and (3) an end cap which holds the filtering element and forms a sediment chamber.



With an input pressure of 100 psi and the output pressure regulated to 20 psi, the unit has a maximum air capacity of about 12 standard cu. ft/minute. The unit can be either pipe line or flush panel mounted.

Minneapolis-Honeywell Reg. Co., Wayne & Windrim Aves., Philadelphia 44, Pa.

Midget-Type Industrial X-Ray Machine

Less than half the size and less than ⅛ the weight of the conventional quarter-million-volt unit, a midget-type industrial 250,000 v x-ray machine is capable of x-raying steel up to 3½ in. in thickness. The unit is light weight and mobile, and can be carried around to foundries, welding shops, shipyards, building projects, and on other jobs. It is less than 15 in. in dia. and 44 in. long; and weighs 150 lb as compared to 1,150 lb. for conventional units.

A feature of the unit is its protruding "snout" from which the x-rays are emitted, making it possible to take "inside-out" x-ray pictures. Its first use has been in shipyards where it is used to inspect welded seams and stressed areas in ships during and after construction.

Operating at from 75,000 to 250,000 volts, the new unit can be used on anything from magnesium to steel. Use of the machine on light metals is also aided by the beryllium "window" of the x-ray tube, which allows the escape of softer, less penetrating x-rays from the tube.

General Electric Co., 4855 Electric Ave., Milwaukee 14, Wis.

CONTINUED ON PAGE 219

24-HOUR PROTECTION

New Norgren Automatic-Drain Filter

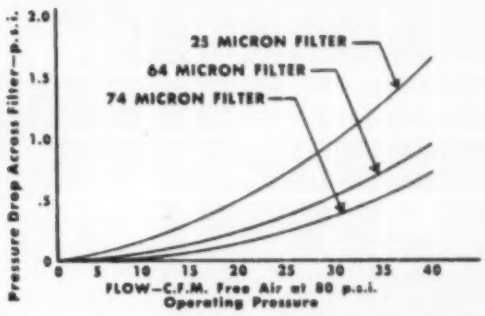
AUTOMATICALLY **cleans the air**

AUTOMATICALLY **drains the filter**

INCREASES **air power efficiency**

REDUCES **air line and equipment maintenance costs**

LOW PRESSURE DROP!



Excessive pressure drop means inefficient air equipment performance, slowdowns in production, unusually high compressed air costs

AUTOMATIC—WITH OR WITHOUT AIR FLOW

Now you can have dependable, around-the-clock protection against damaging results of moisture in your compressed air lines—without attention. This amazing new Norgren Automatic-Drain Filter efficiently removes solids and liquids from air lines. And the drain operates automatically under constant or fluctuating air pressure, with or without air flow. Thus, it extends equipment life, reduces maintenance costs, improves equipment performance.

SIZES: for ¼", ⅜", ½" air lines
FLOW: 0 - 35 cfm
PRESSURE: 30 - 150 psi
TEMPERATURE: +40° to +120° F.

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SCIENTIFICALLY COMPOUNDED ELASTOMERS

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When you need an oil-resistant, pliable part with an exact degree of flexibility, hardness, resistance to extreme temperatures, fluids, gases, abrasion and wear . . . whether it be an intricately designed diaphragm or boot . . . or a simple but critical packing or gasket . . . Sirvene will serve you dependably.

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Actual tests prove Sirvis packings require less replacement than any other type. Made in a complete line of cup, flange, U and V types from specially treated and tanned steerhide. Available in special designs, scientifically engineered to solve unusual situations.

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The "Perfect" answer to fluid retention, moisture and foreign matter exclusion, and similar mechanism protection problems. Used more than any similar device in motor vehicles, industrial machines, farm implements, and road machinery. Stocked in over 1800 sizes, covering 16 different types.

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SERVING 1878 1953 75 C/R FIFTH ANNIVERSARY

CHICAGO RAWHIDE MANUFACTURING COMPANY

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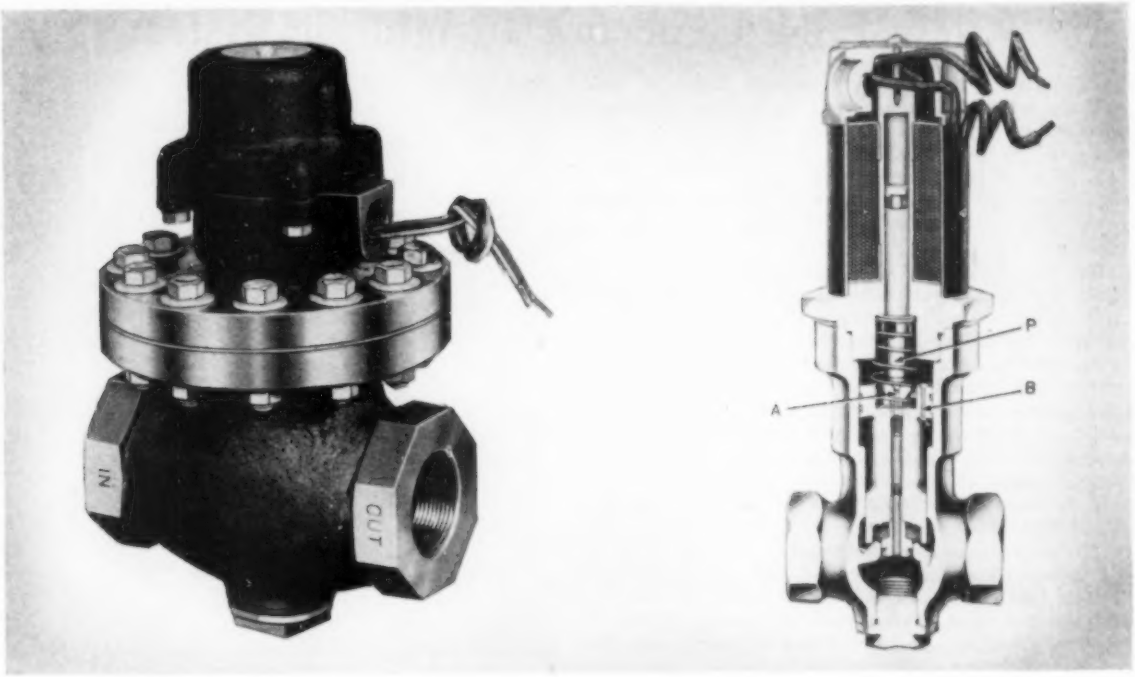


Automatic Solenoid Valve Eliminates Shock

The main feature of a line of electrically operated valves is the adjustable timing on the closing stroke, which is available on all valves to 300 psi. This eliminates shock on supply lines, particularly on hydraulic operations. This timing on the closing valve would take a maximum of 30 seconds, with the line pressure being the main actuating force.

Other solenoid valves are available for pressures up to 3,000 psi. The valves are packless, and are designed to handle hydraulic operations, oil, water, steam, air, gases, and anything not harmful to bronze. All parts are accessible without removing the valve from the line.

The cutaway view is that of the type A valve, which is normally closed. Operating pressures are from one to 300 psi for oil, water, air, gas, and steam. Sizes are: $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, and $1\frac{1}{2}$ inches.

To open: when the current is applied, the plunger lifts the pilot valve (P), relieving the pressure on top of the piston through pilot seat orifice (A). Since this orifice is larger than the timing screw orifice (B), pressure on the lower side of the piston is greater, and the line pressure opens the valve.

To close: the current is cut-off. Pilot valve (P) closes escape orifice (A), causing pressure to equalize above and below the piston through the timing orifice (B). The spring returns piston to the closed piston and the line pressure holds the valve closed.

The other type of valve shown is the type HP-SS-X, made of stainless steel and available for special applications. Pressures are to 3,000 psi in a size of $1\frac{1}{2}$ inches. Another valve with pressures to 3,000 psi is the model HP. Each valve requires a relay to protect the primary coil winding. Sizes in this model are: $\frac{1}{2}$, $\frac{3}{4}$, and one in., with the one in. size having a $\frac{3}{4}$ in. port.

Standard coils are paper insulated, vacuum impregnated, and baked for moisture resistance. Glass-insulated coils available for high temperatures.

Atkomatic Valve Co., 545 *W. Abbott St., Indianapolis, Ind.*

NEW OVAL TYPE WIRE WOUND RESISTORS, said to give higher wattage ratings within small space limitations are equipped with an aluminum mounting strip to give cooler operating temperatures and greater dissipation of heat caused by contact with the ceramic core. Spacers attached to the ends of the aluminum strip permit easy stack mounting and better heat conduction to the mounting surface. The resistors are available in 10 watts, $\frac{3}{8}$x$\frac{3}{4}$ in. and 15 watts, $\frac{3}{8}$x1 in. sizes. The resistors are wound on oval Steatite cores with silver soldered connections and coated with a brown vitreous enamel. Milwaukee Resistor Company, 700 W. Virginia St., Milwaukee 4, Wis.

A PUTTY-LIKE COMPOUND that comes in a roll and applies like tape is designed to insulate, pad sharp edges, and fill voids around irregular-shaped connectors. It has a dielectric strength of 350 volts per mil, and insulation resistance of 100,000 megohms. Minnesota Mining & Mfg. Co., 900 Fauquier St., St. Paul 6, Minn.

CONTINUED ON PAGE 220

New Pulse Generator In Ignition System

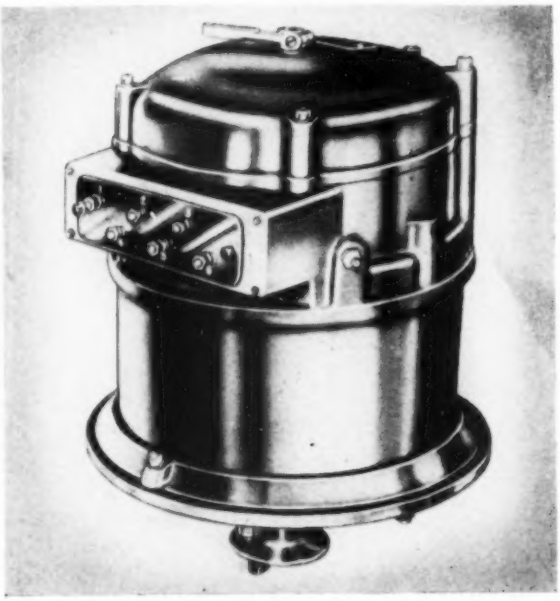
Based on the development of a new design of pulse generator, which, like the magneto, is a device for the timed firing of fuel mixtures, a new self-powered ignition system is capable of producing output potentials up to 30,000 volts. Said to give more efficient operation of high-compression natural gas engines, it will allow engines to run at least 6 months without shutdown, even for spark plug inspection.

The new generator is designated as the Pulse Generator MGC. It measures approximately 11¼ in. in dia and stands about 12½ in. above its mounting, supplying timed low tension electrical pulses which are stepped up to the required spark potential by means of either single or double ignition transformers mounted on each cylinder near the spark plug or plugs. The ignition transformers are model CLQ (single-spark) or model CLP (two-spark) types designed for use with the pulse generator. They are hermetically sealed, oil filled, and have closed cores.

In the pulse generator, no breakers are in operation during running and no distributor is used. Breakers are used for starting only, and are automatically retracted mechanically during normal engine operation. Other features include the fact that at operating speeds the rotor and two ball bearings are the only moving parts. At cranking speeds the generator performs as a conventional large magneto. Use of breakers during cranking makes a high voltage spark available.

The magnet rotor is a built-up assembly consisting of a single large Alnico V magnet with laminated pole shoes. Balance is accomplished by a suitable counterweight. Two heavy duty fully sealed ball bearings support the rotor, which is provided with a 16-tooth 20/40 pitch external involute spline at the drive end and a single dwell hardened steel cam at the breaker end.

The laminated stator assembly is positioned between a flanged cast iron drive end housing and a cast iron rear



housing. The breaker plate is mounted on the rear housing. The individual coil leads are carried to a terminal plate. The breaker lift plates are retracted from the cam by a control plate actuated by an arm mounted on the breaker cover.

A spring return device will hold the breakers in the "inoperative" position during normal running. Either gear or coupling drive may be used with the unit.

American Bosch Corp., Springfield, Mass.

Wide Range Measurement of R, C, and L.

Featuring four bridges in one instrument, new impedance bridges are compact instruments for the measurement of resistance, capacitance, and inductance over a wide range. Accuracy for the bridge is: resistance ±0.10 percent; capacitance, ±0.25 percent; inductance, ±1.0 percent.

Measurements can be made over ranges: Resistance: 1 milliohm to 11 megohms; Capacitance: 1 micromicrofarad to 1100 microfarads; Inductance: 1 microhenry to 1100 microhenrys; Storage Factor of Inductors (Q) 0.02 to 1000; Dissipation Factor of Capacitors (D) 0.001 to 1.0.

The Model 850-B Amplifier is battery operated for portable field use. The model 855-A1 Amplifier-Oscillator converts the bridge for a-c power line operation and provides both d-c and a-c generator voltages in addition to null amplification and visual null indication. With this unit, a precision of balance of better than 0.02 percent is possible on most measurements. Overall size of the bridge complete with amplifier is 9 in. x 11 in. x 11 inches.

Brown Electro-Measurement Corp., 4635 S. E. Hawthorne Blvd., Portland, O.

CONTINUED ON PAGE 222

No better source of piping information ...than your handy CRANE catalog

Faced with a piping problem? Turn then to your handy Crane Catalog and see how quickly you find the answer.

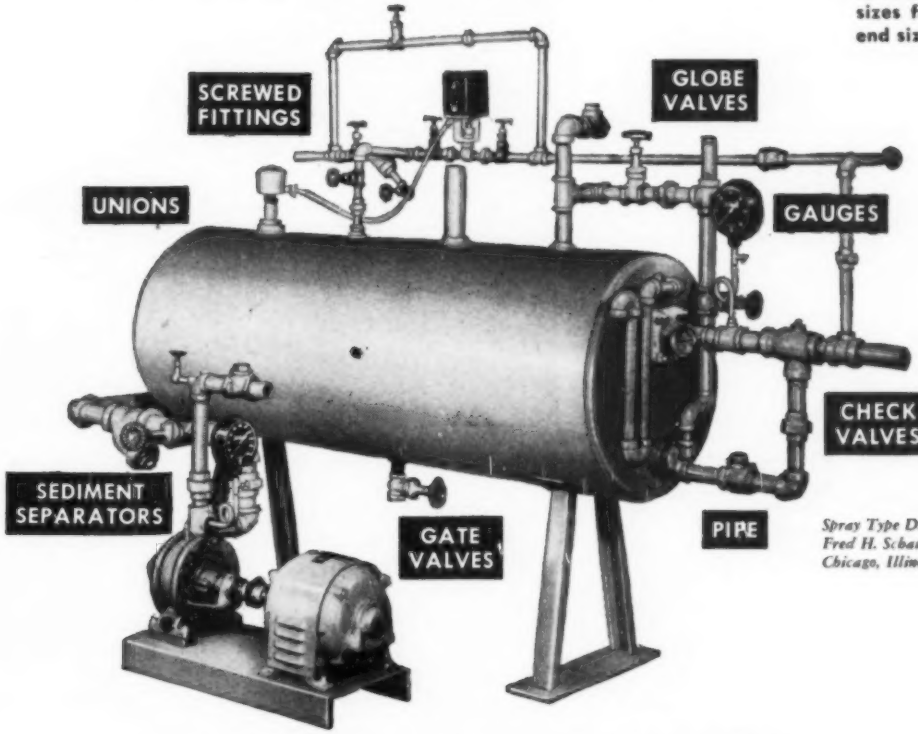
For within the 600 pages of this valuable book is full information on the world's most complete selection of quality piping materials—sizes and dimensions, tabulated pressure and temperature ratings, design, material and construction details, plus recommended applications. And it's all there indexed and arranged to save you time. In addition, you'll find an abundance of general engineering information.

Yes, specifying from your Crane Catalog is easier, quicker *and also safer* because you are specifying the finest piping available anywhere—piping that is recognized by machinery buyers for its dependable service and long range economy.

YOUR BEST BRASS CHECK

for hot and cold service in the 200-300 pound class—is this regrinding-type Swing Check Valve. Of simplified Y-Pattern design with a sturdy body of Crane Special Brass, it assures smooth flow with minimum resistance, and fast action in backflow. Easily reground without removing from line. Screwed end sizes from ¼ to 3-inch; Flanged end sizes from 1 to 3-inch.

NO BETTER SOURCE OF QUALITY ...THAN THE COMPLETE CRANE PIPING LINE



Spray Type Deaerating System by Fred H. Schaub Engineering Co., Chicago, Illinois

The Complete Crane Line Meets All Your Valve Needs. That's Why—
More Crane Valves Are Used Than Any Other Make!

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

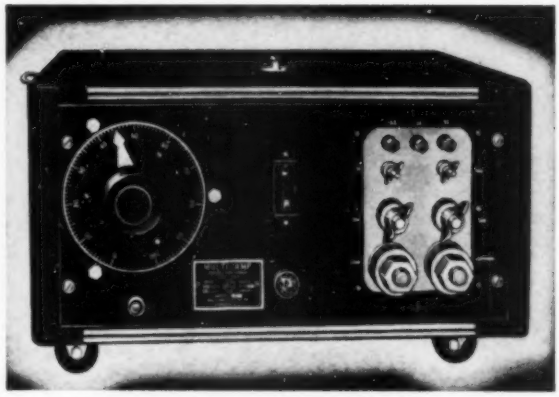
Portable High Current Test Unit

The principle uses of the new model 1005 include testing and calibrating: oil circuit reclosers, CSP transformer breakers, sectionalizers, branch (secondary) circuit breakers, motor overload relays, current transformers, instruments, and overcurrent relays of the "CO" type.

Model 1005 is rated at 2.5 kva output; 220 V, 12 amp (max.) input. The output can be adjusted from 0 to 1,000 amp in eight ranges: 0-12.5, 0-25, 0-33, 0-50, 0-100, 0-250, 0-500; and 0-1,000 amperes. The corresponding terminal voltages are fully adjustable from zero to 115 percent of: 200, 100, 75, 50, 25, 10, 5, and 2.5 volts.

The input to the unit is protected by a circuit breaker which also protects the supply line and serves as an on-off switch. A fuse is used in the circuit between the variable auto-transformer and the special "step" transformer.

Multi-Amp Corp., Harrison, N. J.



Back-Up Washers for Hydraulic Systems

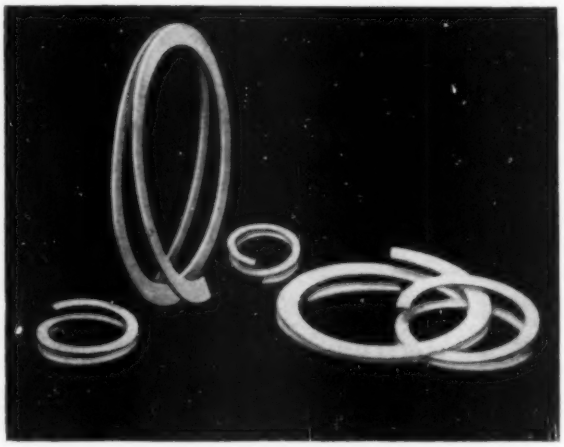
Teflon spiral back-up washers which are used in conjunction with O-ring seals have application in the preventing of extrusion of O-ring seals in hydraulic systems operating above 1500 psi, at temperatures in excess of 200 F.

The reason for this is said to be the properties of Teflon which offer such advantages as: (1) withstanding continuous operation at temperatures from —110 F to 500 F; (2) reducing friction and abrasion on the O-ring and therefore increases the life of the entire assembly; (3) washers are non-fraying and are inert to all oils.

The washers are machined to close tolerances form Fluroflex-T tubing, said to be of uniform density and tensile strength, and stress relieved to provide dimensional stability of washers in storage as well as in service.

Washers are available in sizes from —1 to —31 ($2\frac{1}{4}$ in. outside diameter) which corresponds to the dash numbers of AN 6227 series O-rings.

Resistoflex Corp., Belleville 9, N. J.

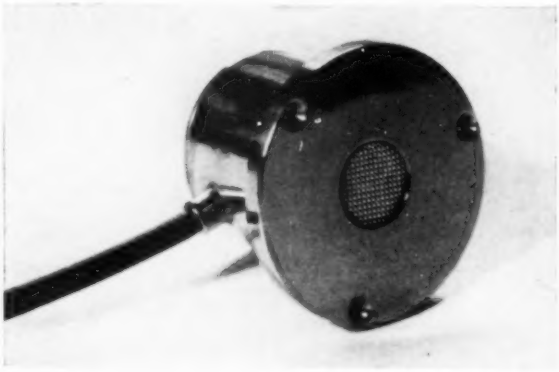


Sensitive Electrokinetic Pressure Transducer

By using the streaming potential developed by a polar liquid flowing through a porous plug, a new electrokinetic transducer has a high sensitivity means of measuring fluctuating or transient pressures over extended ranges of both amplitude and frequency. In the shape shown, the case may be baffllle mounted for measuring air blasts up to 100 psi, or adapted to measure pressures in pipes or tubing.

The unit provides a sensitivity of 250 millivolts per psi at a resistive output impedance of less than 100,000 ohms. The frequency response at the diaphragm extends from 0.25 cps to above 30 kc. The type 3 pressure transducer requires no external power source and the sensitivity at midband frequencies is unaffected by cable length. Noise level equivalent of well below 5×10^{-5} psi makes is possible to measure sound pressures as low as 10^{-4} psi.

The Beta Corp., P. O. Box 8625, Richmond 26, Va.



CONTINUED ON PAGE 224

CONTINENTAL'S PROOF BOOK

E. J. GIVENS

Pennsylvania State College, B. S., 1944. Joined New York Wire Cloth Co. in 1948 as Industrial Engineer and became Purchasing Agent in 1950. Secretary of York Purchasing Agents' Assn.; member of National Assn. of Purchasing Agents; Purchasing Agents' Assn. of Phila. and Society for Advancement of Management.

Incorporated 1912

NEW YORK WIRE CLOTH COMPANY
441 EAST MARKET STREET
YORK, PENNSYLVANIA

GENERAL OFFICES
NEW CANAAN, CONN.

February 11, 1953

Continental Screw Company
New Bedford, Massachusetts

Gentlemen:

As manufacturers of a new kind of product--the Durall aluminum tension screen--we have been in an excellent position to appreciate Continental Screw's quality and service. For instance, we must have a screw that even a housewife can drive, and with a head large enough to seat properly in our screen clamp bracket. The screw that you designed for us has more than met our specifications.

Another feature that has resulted in additional sales appeal for our product is your method of fastening our screws on a tape, which has been pre-printed with our Durall brand name. This tape has proven a very convenient method of insuring that the exact number of screws reaches each customer.

Over a period of twelve months, our production schedules fluctuate, but whenever this happens you respond promptly with every possible effort to keep our line operating. We want you to know that this type of performance rates very high with us.

These extras, plus a top quality product, have given Continental the number one spot on our vendor list for screw requirements. It has been a pleasure to work with you during the past and earnestly hope this same association will continue for many years.

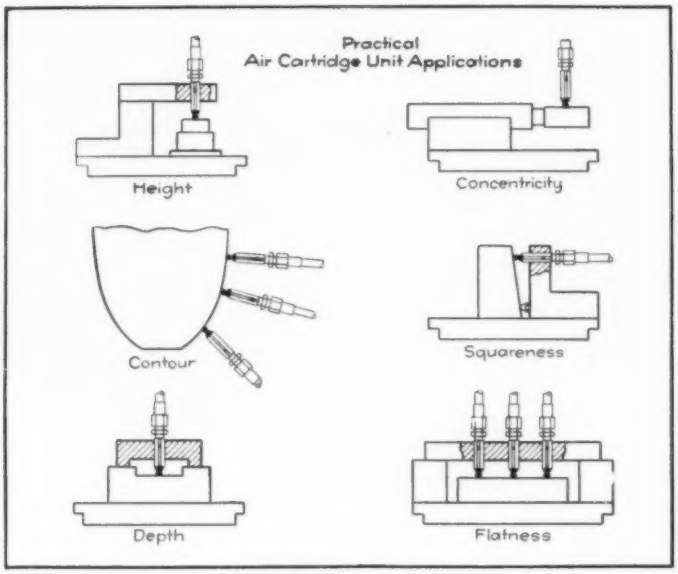
Sincerely,
E. J. Givens
E. J. Givens,
Purchasing Agent

You too can count on Continental®

CONTINENTAL SCREW COMPANY INC. 1904

Manufacturers of HOLTITE Fastenings For Every Purpose

CONTINENTAL SCREW COMPANY, NEW BEDFORD, MASS., U.S.A.



Air Gaging Device Has Wide Application

Checking such factors as squareness, height, contour, concentricity, flatness, and depth, are some of the applications of the air cartridge unit. Used with Air-O-Limit gages, also developed by this company, this gaging device can be used in both single and multiple station fixture-type gages in the same manner as dial indicators are used.

The unit consists of a plunger with a contact point on one end and a stainless steel ball on the other end operating with axial movement in the cartridge body. Air flow through the cartridge unit is restricted by the ball on the plunger operating in a tapered hole in the body, setting up back pressure required to operate the Air-O-Limit gage. A contact of three ounces is all that is needed to operate the unit.

Internal and external average diameters can be checked by using multiple cartridge units in a gaging plug or ring. Large diameter parts having broad out-of-round tolerances that must be checked for average diameter, can be measured by using these air cartridge units in multiple.

The unit can be applied to machine tools to indicate runout. As a direct size indicator it will give an indication as the finished dimension is approached.

Height gage applications in connection with surface plates, can be made by mounting the cartridge unit on a height gage stand and using it in conjunction with a comparator.

The broad scale air cartridge unit, is correctly calibrated by means of a set of minimum and maximum feeler gages, eliminating the necessity of calibrated masters. Once magnification is established with the feeler gages it may be applied to any fixture and zeroed with a setting master.

The unit measures $1\frac{3}{4}$ in. long and $\frac{3}{4}$ in. in diameter. The back of the unit is threaded to fit the standard Natvar tubing for connection to the comparator.

Standard air cartridge units are made primarily for coarse tolerance work and are available in three magnification ranges operating on total scales of 0.010 in., 0.015 in., and 0.020 inch. However, units can also be furnished for total scales ranging from 0.0006 in. up to 0.003 inch.

Pratt & Whitney, West Hartford 1, Conn.

A COMPLETELY PACKAGED, easily installed, general-purpose photoelectric counter for all industrial counting applications, consists of a photoelectric control, light source, and electric counter. The only piece of equipment located at the point-of-count is the control and light source. One or more electric counters may be placed at any convenient location and wired to the control, making remote counting possible. Photoswitch Inc., 77 Broadway, Cambridge 42, Mass.

A FAST DRYING MARKING INK has wide use where materials are to be marked permanently, as the ink will not chip or peel, and is unaffected by heat and weathering. The ink is good for marking rough castings, bar stock, machinery, jigs, tools, dies, fixtures and plates. It is also used on forms in preboarding operations in the textile industry and in other industries. Different size tube applicators, and six different colors are available. John P. Nissen, Jr., Co., Glenside, Pa.

LARGE-CAPACITY HEAVY DUTY CENTRIFUGES for the operational testing of components and assemblies under high centrifugal and acceleration loads, will test components or complete assemblies weighing up to 600 lbs., at centrifugal loadings of 60 g's with proportionately higher loadings for smaller test specimens. Test specimens up to 6 ft long and 24 in. in section can be accommodated. Variable speed regulation is possible. The Ruckner Co., 4228 Hollis St., Oakland 8, Cal.

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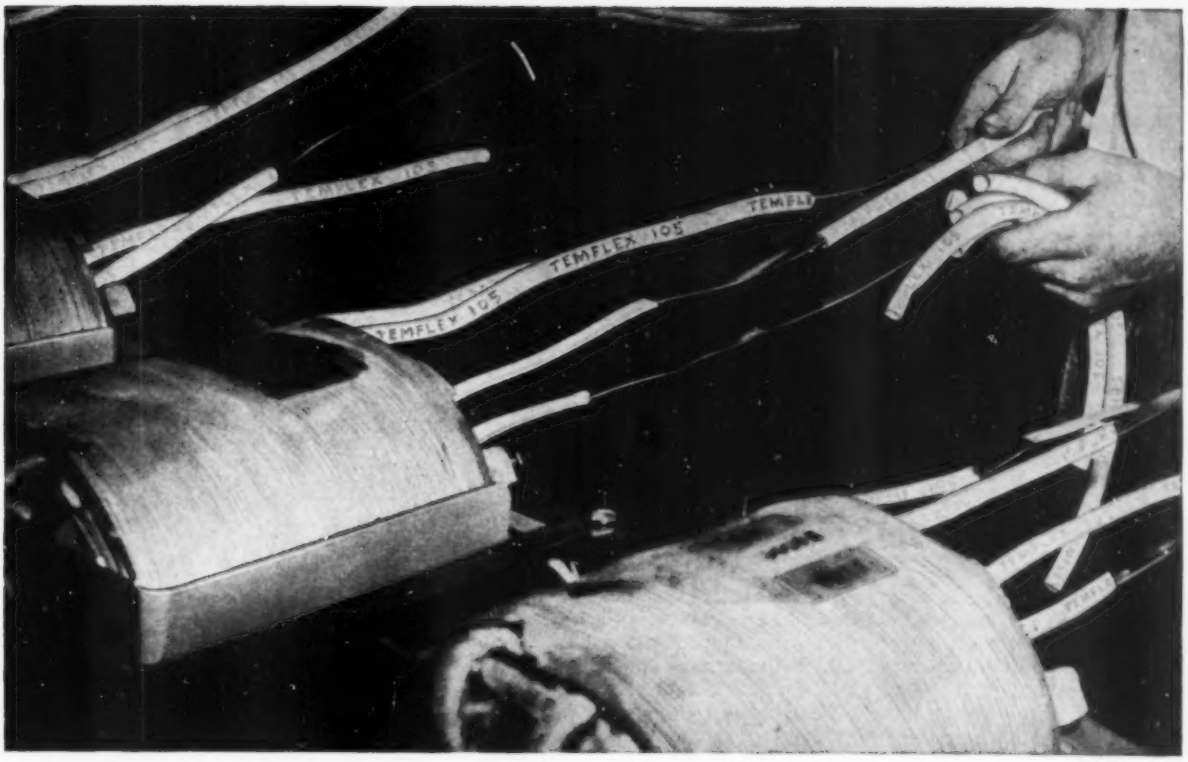


Wagner Electric reports "Long Life" when transformer leads are insulated with TEMFLEX 105

Lengths of Irvington's Temflex 105 Plastic Insulating Tubing are quickly and easily slipped over transformer leads at Wagner Electric Corporation. And once they're in place, they're there to *stay* through the toughest service.

This product of Irvington's Fibron division is approved by Underwriters' Laboratories for *continuous* operation at 105° C.—and for 90° C. operation *in oil.*

Temflex 105 Tubing *retains* its original high dielectric strength of 1100 vpm, its flexibility and excellent elongation characteristics even after continuous high-temperature operation, varnishing, baking or immersion in chemicals.

Produced in all standard colors, readily identified by the continuously printed name on the smooth tubing surface. Identify it by name when you buy!

A Technical Data Sheet is yours for the asking — just mail the coupon.

Look to
IRVINGTON
for Insulation Leadership
INSULATING VARNISHES
VARNISHED CAMBRIC
VARNISHED PAPER
VARNISHED FIBERGLAS
INSULATING TUBING
CLASS "H" INSULATION

Send this convenient coupon now

Irvington
VARNISH & INSULATOR COMPANY
10 Argyle Terrace, Irvington 11, New Jersey
Plants: Irvington, N. J.; Monrovia, Calif.; Hamilton, Ontario, Canada

PE-3/53

Irvington Varnish & Insulator Co.
10 Argyle Terrace, Irvington 11, N. J.
Gentlemen:
Please send me Technical Data Sheet on Temflex 105 Tubing.
Name.....Title.....
Company.....
Street.....
City.....Zone.....State.....

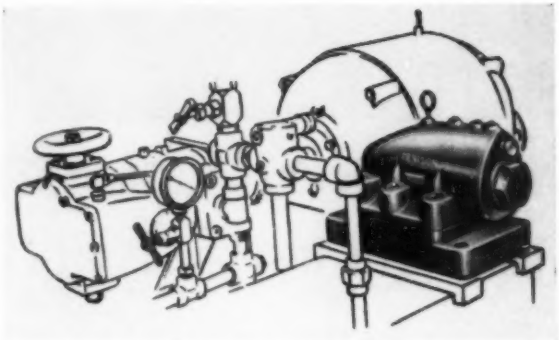
Hydraulic High-Pressure Control Valve

With a low differential between opening and closing pressures, a new two-inch hydraulic relief valve is built to provide pressure control up to 5000 psi, with volume capacities up to 125 gpm. The low differential results in faster action, closing pressure control, and a reduction of over-pressure and pressure-drop conditions.

Greater efficiency, resulting in better circuit operation, is said to be possible by the close fit of all sealing surfaces within the valve body, reducing leakage to almost zero. Pressure setting is adjusted by a knurled screw on the valve cap, with provision also made for remote control of this regulation.

Known as the Hydroilic relief valve, the valve is furnished with either threaded body or for subplate mounting. While in the average hydraulic circuits, the flow limits the volume capacity of the relief valve, the manufacturers claim that with this new valve, greater than normal volume can be controlled, if the valve is T'd off the pressure line; then oil flows through the valve only when relieving the circuit in excess pressure setting.

When using the subplate type mounting, the relief valve is necessarily T'd off the pressure line, because of its design. The piping is connected to the subplate and the valve is mounted on the plate. This type of installation provides a means of removing the valves at any time without having to break the pipe connections. And, in cases of higher pressure installations where heavy pipe is required, the distortion caused by the threading of pipe is eliminated. For more information on this and other relief, sequence, and unloading valves for high-pressure, write to the manufacturer.



The Denison Engineering Co., Columbus, Ohio

Electronic Variable Speed Drive Units

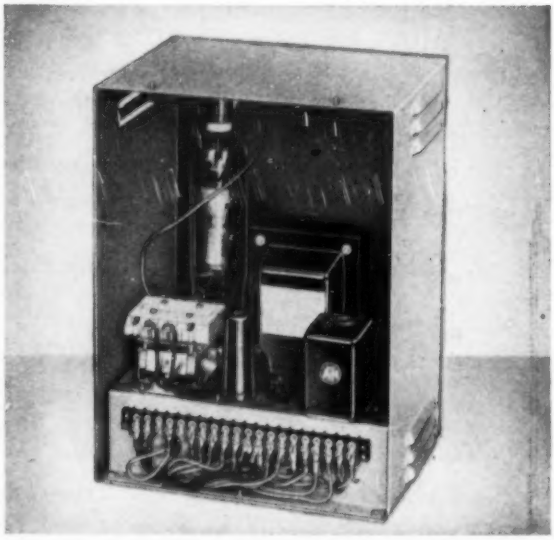
Consisting of an electronic adjustable speed control unit driving a series motor, a packaged electronic variable speed drive for fractional horsepower motors has a wide, stepless range of speed control with good speed regulation under varying loads. With an optional dual range feature, speeds from 100 to 3500 rpm are available. The motor can be started, stopped, or dynamically braked, and can be rapidly accelerated to preset speeds.

Using the series motor instead of the shunt motor makes use of both the a-c and d-c output from a single thyratron tube, and it is claimed that this results in higher speeds at medium torque, higher starting torque at slow speeds, and longer tube life.

As a pilot device, a push-pull selector switch will be used. The manufacturer states that where multiple operations are involved, this will give single point control and, in addition, will conserve space.

Inherent compensation is 10 percent of line voltage and 5 percent of speed, but full voltage compensation is also available as an extra feature.

The Arrow-Hart & Hegeman Electric Co., 103 Hawthorn St., Hartford 6, Conn.



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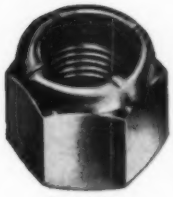
self-locking fasteners

Elastic Stop nuts



HEX NUT

SPLINE NUT

HIGH TENSILE NUT

CLINCH NUT

1200° F. HIGH-TEMP. NUT

GANG CHANNEL NUTS

FLOATING ANCHOR NUT

Every major aircraft now being assembled relies on the vibration-proof holding power of ELASTIC STOP nuts. Only ESNA manufactures a complete line of all types and sizes of self-locking nuts.

Rollpins

dia. from 1/16" to 1/2"

Rollpins are slotted, tubular steel, pressed-fit pins with chamfered ends. They drive easily into holes drilled to normal tolerances, compressing as driven. Extra assembly steps like hole reaming or peening are eliminated. Rollpins *lock* in place, yet are readily removed with a punch and may be reused.

Cut assembly costs by using Rollpins as set screws, positioning dowels, clevis or hinge pins. Specify them in place of straight, serrated, tapered or cotter type pins.

ELASTIC STOP NUT CORPORATION OF AMERICA

ROLLPIN TRADEMARK

Mail Coupon for Design information

Elastic Stop Nut Corporation of America
Dept. N34-32 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

- ☐ Elastic Stop Nut Bulletin
- ☐ Rollpin Bulletin
- ☐ AN-ESNA Conversion Chart
- ☐ Here is a drawing of our product. What fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

Fractional HP Variable Speed Motor Pulley

The new operating principle of the Var 'A' Cone variable speed pulley permits the use of standard "A" section belt. The telescopic feature of movable disk eliminates interlocking disks, reduces belt wear and vibration, and permits variable speed changes within $2\frac{3}{4}$ to 1 ratio.

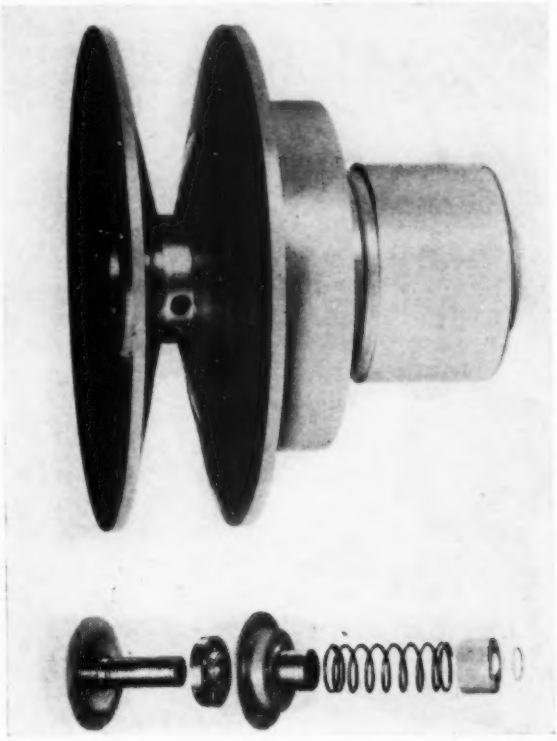
Easy to install and maintain the Var 'A' Cone adds variable speed economically to equipment in the light horsepower field such as lathes, saws, drill presses, blowers, and packaging machinery. It also adds further economy by multiplying belt life because the pulley disks are smooth all the way to the minimum pitch diameter. Speed change is made while the equipment is running.

The variable speed pulley is machined of cast iron. No lubrication is necessary, as bushings are of the oil-impregnated type. Through shaft mounting is also possible. The unit is rated up to $\frac{3}{4}$ hp at 1750 rpm., and at $\frac{1}{2}$ hp at 1160 rpm. Maximum pitch dia. is 4.75 in., and min. pitch dia. is 1.73 inches. Motor travel is $2\frac{3}{8}$ inches.

The design of this unit comprises three basic units: The stationary disk; the inner sliding disk; and outer sliding disk in addition to the usual spring and spring cover.

To allow the outer sliding disk to bring the belt to the maximum pitch diameter, the inner sliding disk recedes within the outer sliding disk cavity. As the pulley opens and the pitch diameter decreases, spring loaded pins contained within the inner sliding disk are forced out of a groove in the shaft and into a groove in the sliding disk, thus making the inner and outer sliding disk one unit. This allows the belt to ride on a smooth surface to the minimum pitch diameter without interruption.

When the pulley closes, the pins fall back into the groove in the shaft, releasing their hold to the outer sliding disk, permitting the belt to move to the maximum pitch diameter.



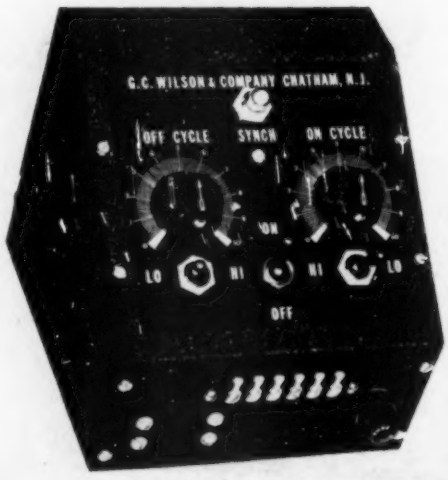
Gerbing Mfg. Corp., Northbrook, Ill.

Repeat Cycle Timer Has Wide Use

An electronic repeat cycle timer suitable for regulation of automatic machinery, sampling, valve pacing and heat sealing as well as laboratory testing, uses a single electron tube to charge a resistance-capacitance network so that "on" cycles are adjustable from 0.2 to 200 seconds, and "off" cycles range from 0.1 second to 1 minute. Operation is such that one cycle initiates the next cycle without any moving parts or external operation.

The unit is supplied in a sloping steel front cabinet, 6 in. x 6 in. x 6 in. for operation on 105-120 volt, 60 cycle a-c. Output is supplied to a double pole double throw relay for non-inductive loads up to 10 amperes at 115 volts or 2 amperes at 460 volts. Relay contacts are wired to a plug or a terminal strip to simplify installation, and are resistant to shock and vibration.

Applications in which the timer has been used include: refluxing; sign flashing; filter cleaning; heat cycling; life testing; food processing; sampling; electro plating; plastic molding; mixing machines; bag filling; bottle filling; valve metering; photo printing; tube testing; and flight testing.

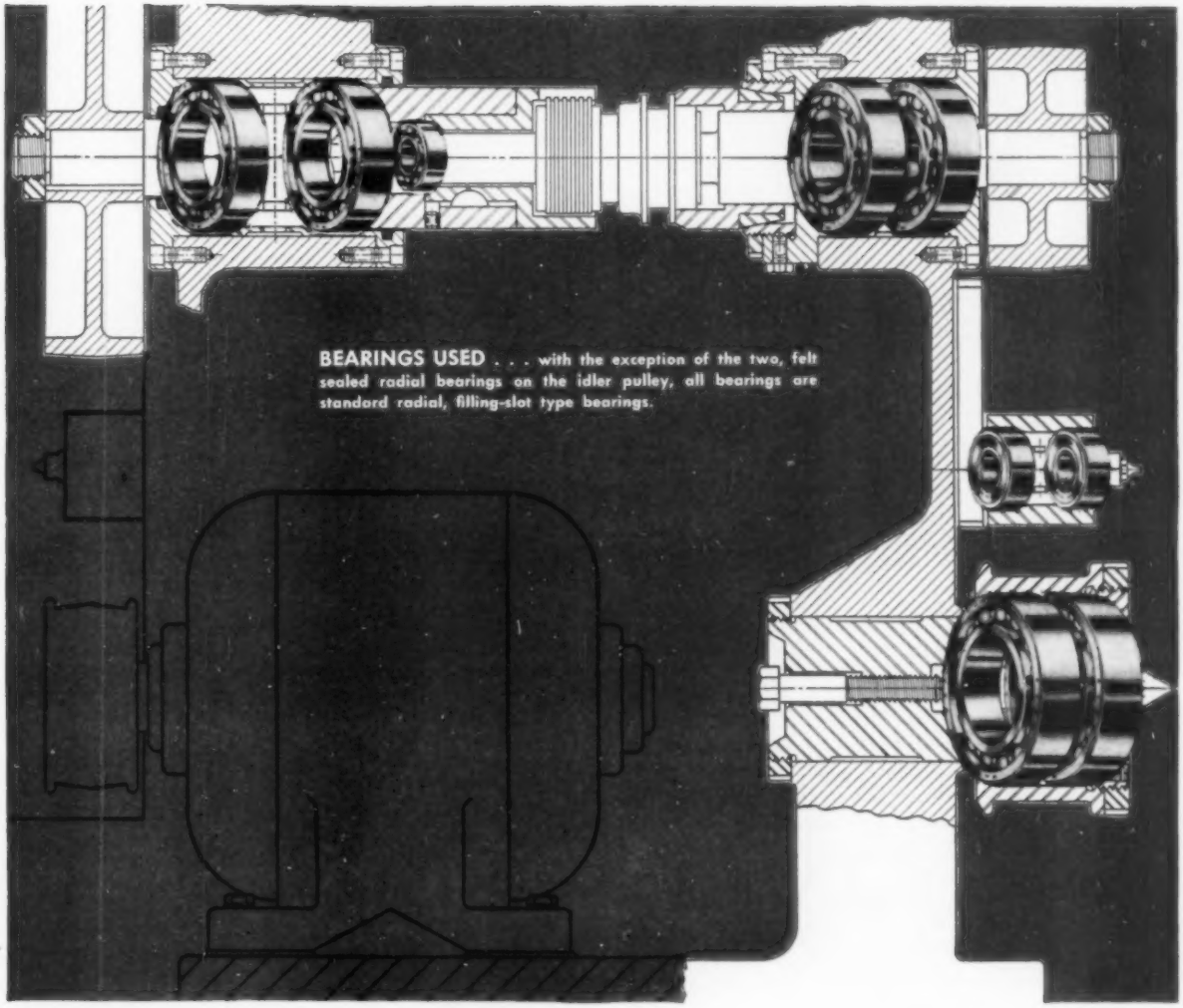


G. C. Wilson & Co., 2 North Passaic Ave., Chatham, N. J.

CONTINUED ON PAGE 230

Modernize by Motorizing!

RIGHT ANGLE to a grinder problem


BEARINGS USED . . . with the exception of the two, felt sealed radial bearings on the idler pulley, all bearings are standard radial, filling-slot type bearings.

Here's an idea that may be helpful to you, if you have a problem of motorizing a belt-driven machine. It has already extended the useful service life of a grinding machine by eighteen years . . . and the machine is still in operation.

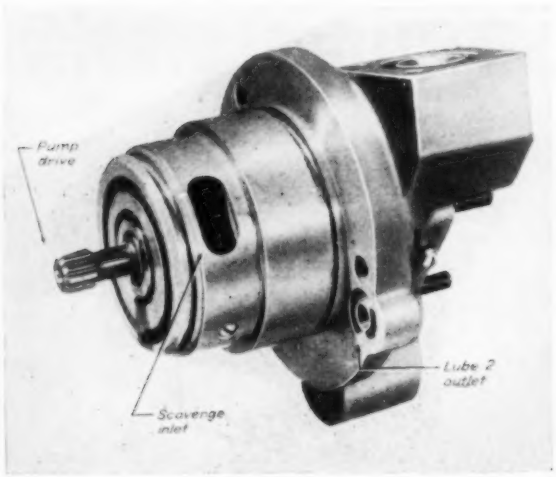
Building the drive around the motor seemed to be the best way to convert the grinder. This right angle arrangement includes nine Fafnir Ball Bearings . . . all grease lubricated. Speed range of drive, 160 to 720 r.p.m. During World War II, the converted machine was in operation 24 hours a day . . . now it's on two, 8-hour shifts daily. No bearing replacements have been made since the conversion.

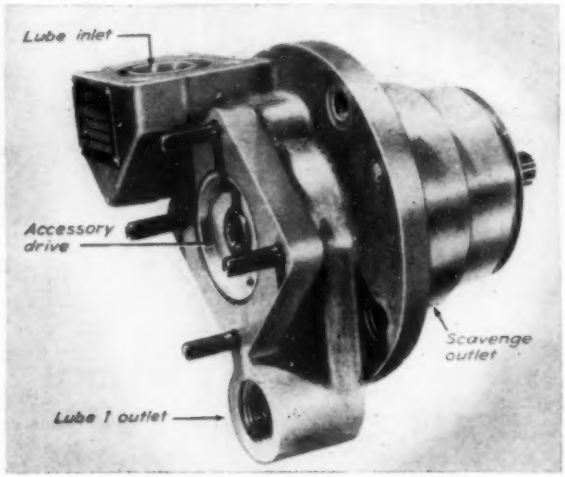
Here's another example of the Fafnir "attitude and aptitude" . . . a way of looking at bearing problems from the user's viewpoint, an aptitude for providing the most effective solution based on more than 40 years' experience. Whatever your bearing problem, a few minutes spent with a Fafnir Representative may help you solve it successfully. The Fafnir Bearing Company, New Britain, Conn.

FAFNIR

BALL BEARINGS

MOST COMPLETE LINE IN AMERICA





Three Element Lubrication Oil Pump

For gas turbine engines, a combination of two pressure pump elements and one scavenge pump element is contained in one main lubricating oil pump. Supplementing the three elements and adding to the utility of the pump, the housing contains a mounting pad for a tachometer or other accessory drive.

Only two external ports require pipe connections, and internal porting of three remaining oil circuits is accomplished through direct contact of pump ports with internal circuit connections of the engine.

The rated capacity of each pressure element is 2.5 gpm; and 6 gpm for the scavenge element. Rated speed is 4200 rpm with discharge pressure of 60 psi and rated inlet pressure of 25-30 in. Hg absolute. Rotation is counter clockwise viewing the spline drive end. The pump requires ½ hp for operation.

Operating range is 350 to 5000 rpm with suction inlet pressures to 3 inches Hg absolute. Temperatures to —65 F are met through use of jet lubricating oil, grade 1005 (MIL-0-6081), as the pumping medium. Each element is a positive displacement, non-pulsating, rotary vane type. Each of the two pressure elements displaces 0.150 cu. in./rev. and the scavenge element 0.367 cu. in./revolution.

The pump contains no valves, shaft seals or packings, except a shaft seal at the accessory mounting pad to prevent oil leakage. Other features are long life and minimum maintenance. Total weight is 3.5 pounds.

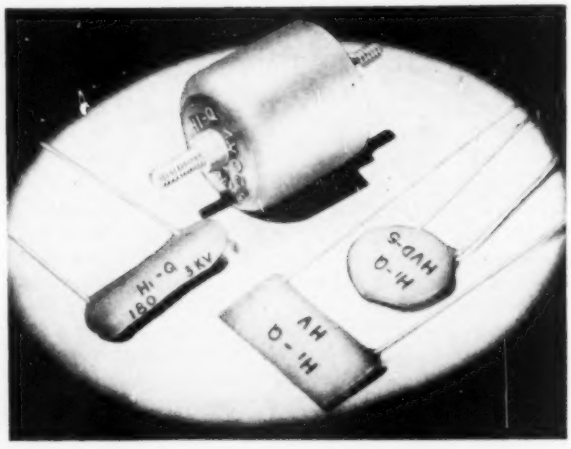
Lear, Inc., Romec Div., Elyria, Ohio

High-Voltage Ceramic Capacitors

Voltage ratings of from 1 to 20 KV are now made available in ceramic capacitors of the slug, disk, plate and tubular types.

In the new slug type utilizing thick disk dielectrics, the strength of the capacitor is increased by a jacketing procedure with a new plastic having good arc-resistant properties. Terminals are silvered brass soldered to silver electrodes and fired directly to the ceramic dielectric. Insulation resistance is about 50,000 megohms. Working voltage is 20,000 d-c, and flash test 27,000 V d-c.

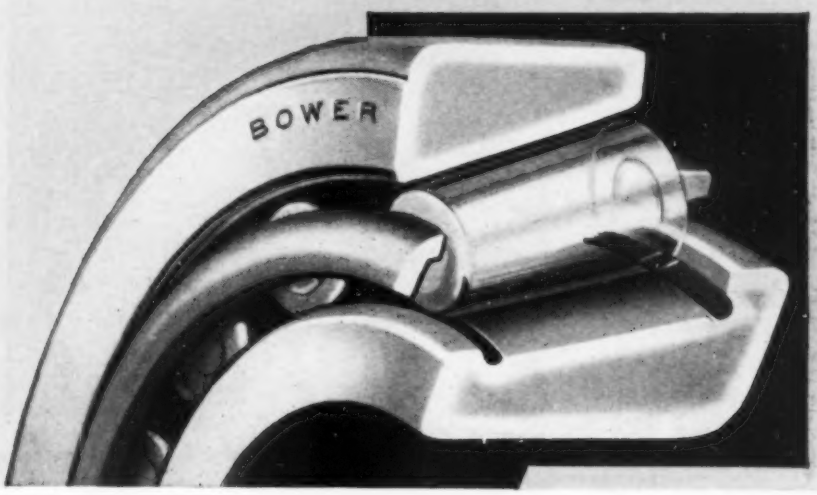
The high-voltage disks are available in various capacities and voltage ratings. The high-voltage tubulars have been developed specifically for use in horizontal sweep and deflection sections of TV receivers, and come in standard capacitances from 4.7 to 1000 mmf., voltage pulse ratings of 1 to 7 KV and capacity tolerances of ±5 percent. Physical sizes are based on operational specifications.



Aerovox Corp., Hi-Q Div., Olean, N. Y.

CONTINUED ON PAGE 232

Bower spher-o-honed design provides better bearing lubrication



LARGE OIL GROOVE GIVES POSITIVE LUBRICATION TO ROLLER HEADS

The large oil groove built into Bower Spher-O-Honed bearings is just *one* of several important Bower design features which reduce maintenance and increase efficiency. Combine it with generated spherical roll-heads and a higher flange surface, and smooth, precision-honed races, and you have the basic elements of Spher-O-Honed design.

A careful look at the illustration above will show you other important Bower features, too. Note particularly that the roller heads contact the flange over a wide two-zone area—thus reducing wear and minimizing resultant "end play."

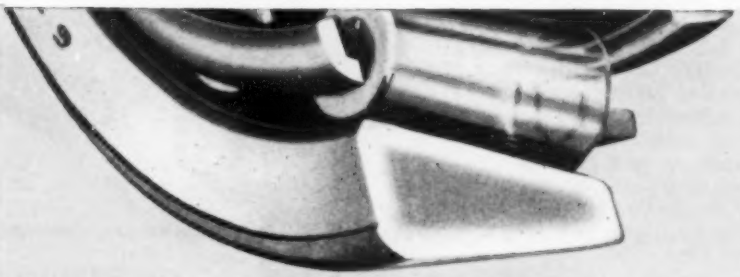
Built of the highest quality materials and workmanship, Bower bearings are available in a complete range of sizes and types to meet your present requirements. Call in a Bower engineer now!

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN

BOWER

ROLLER BEARINGS

SPHER-O-HONED



A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS

Production Comparator Reduces Testing Time

The Production Comparator is a differential-type vacuum tube voltmeter which indicates differences between the magnitudes of two a-c input voltages, audio or ultrasonic. Usually, one input is applied from a production unit under test, while the other input is applied from a similar unit whose performance represents design objectives. The comparator difference-reading measures deviations between the responses of the two units. There are two meter scales, a linear scale calibrated in percent, and a logarithmic scale calibrated in ± decibels.

The instrument consists of two vacuum-tube voltmeter circuits which are exactly matched. Their outputs are rectified and are applied to a differential meter circuit so that the meter reads the difference between the inputs. The voltages are rectified before they are combined, and the reading is unaffected by the relative phase or frequency of the input.

The comparator is adaptable to almost any repetitive testing in which the responses can be made proportional to a-c voltages, linear or nonlinear, low or high frequency. The comparator accuracy is ±1½ percent. The normal meter range is ±40 percent, with a minimum detectable difference of ±1½ percent, though both range and sensitivity can be increased.

Typical applications are: (1) comparing amplifier, equalizer, and filter responses; (2) as a limit bridge for selecting or matching resistors, capacitors, or inductors; (3) comparing inductors carrying d-c; (4) comparing magnetic modulators; (5) comparisons at radio frequencies; and (6) comparing mechanical vibrations.

Frequency response, 10 cycles to 200 Kilocycles; Accuracy, over the audio frequency range of 20 to 20,000 cycles any error in comparative readings is less than 1/20 of the indicated difference value; Input voltages, ranges of 0.5, 1.5, 5 and 15 v for full scale meter deflection at ±40 percent difference; Input impedance, 1½ megohms in parallel with

50 mmf, two separate shielded input circuits for the standard unknown units.

The values marked on the range switch are nominal and indicate approximately the voltage required to deflect the meter to the red CAL line. These values, 0.5, 1.5, and 15 v, are sufficient for most production testing purposes. It is necessary to select as standard one of these test voltages.

Hermon Hosmer Scott, Inc., 385 Putnam Ave., Cambridge, Mass.

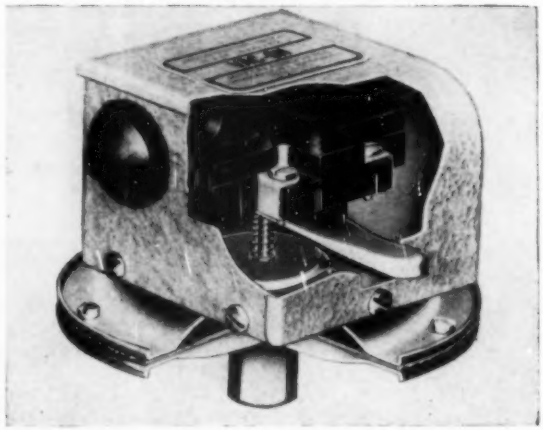
Vacuum Switch Operates As Warning Control

Designed for use with electric motors and gasoline engines, a new vacuum switch has industrial, marine and manufacturing applications as a circuit breaker or control where the safety of equipment depends on a suction-delivered lubricant, fuel, water or similar liquid.

Called the Vac-on switch, it also serves as a warning control where operating conditions depend on: a vacuum; vacuum firing in ceramics manufacture; or the protection of materials in a vacuum.

The switch mounts on the suction line and is wired into the power supply on electric motors, or the spark system on gasoline engines. When suction falls below a predetermined negative pressure, approximately 1 in. mercury, the switch automatically cuts off the motor or gas engine.

Operating on a spring loaded, rubber diaphragm principle, the vacuum switch has silver contact points. The model will operate on electric motors up to 2 hp on a-c and ½ hp on d-c. The gas engine model is designed to short out the spark plug in event of liquid supply failure. A hand lever is used on the switch for manual restart.



Jaycon Associates, 404 N. Washington Ave., Minneapolis, Minn.

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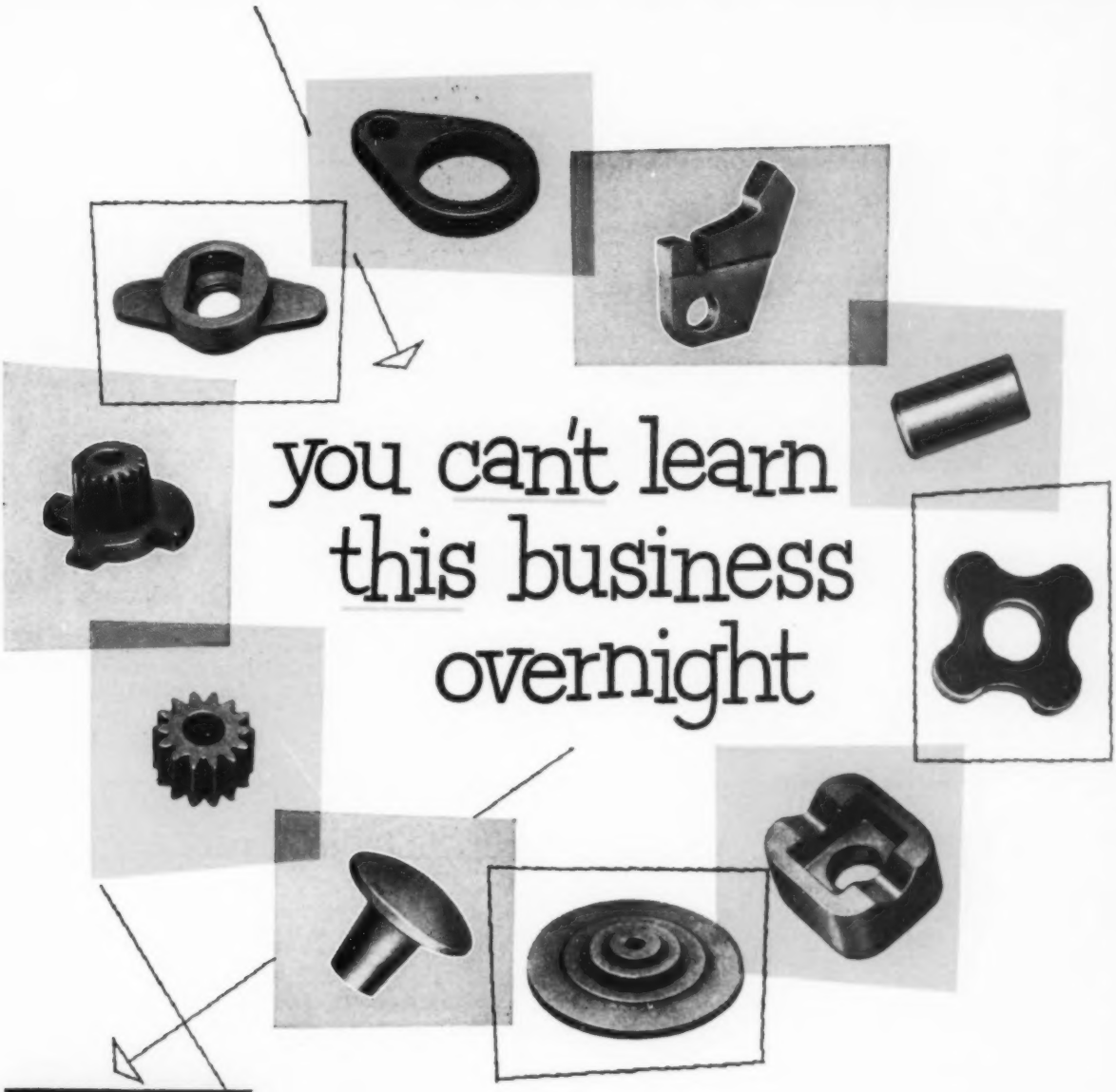


you can't learn this business overnight

METAL POWDER PARTS BY MORAINE

After more than a quarter-century spent in making metal powder parts—*billions* of them—we feel we have amassed an impressive combination of knowledge and experience. And—more important—we continue to learn! The physical properties of our metal powder parts continue to improve; customers are offered an ever-widening choice of materials; parts are produced for ever-widening applications. Yes, we're proud of our position in the field of powder metallurgy . . . proud of the way in which our products continue to serve by improving performance and lowering costs.

moraine products

DIVISION OF GENERAL MOTORS CORPORATION • DAYTON, OHIO

Automatic Control of Flow or Liquid Level

Equipped with a device known as the Conoflow control, a Vari-Speed Motodrive unit may now be used for such specialized applications such as automatically controlling flow or liquid level in tanks.

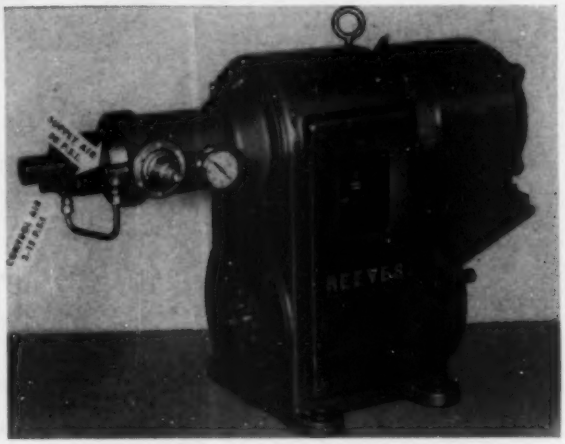
The control may be adapted to such applications where the control or indicators are remote or complicated, such as heat control, humidity control, liquid level, and flow proportioning, whether dry or liquid materials.

The pneumatic controllers used for these applications supply 3 to 15 psi and are connected directly to the positioner of the conoflow cylinder. A separate air supply is then run to the cylinder for shifting the motodrive to a different speed. Maximum stroke is 3 inches. This may be changed by using a different stop collar and range spring.

The cylinder is pre-lubricated and no outside lubrication is necessary. This type control may be operated from the present air supply in a plant, and it can be connected to any pneumatic controlled instrument.

The motodrive unit equipped with conoflow control may be used with any standard NEMA frame motor, and a helical-type gear reducer if required.

The conoflow control is available on all integral horsepower vari-speed motodrives, which have 6:1 maximum speed ranges on all units with capacities to 25 hp.



The standard pneumatic or hydraulic control may still be used where a mechanical connection can be made to an indicating device, such as a dancer roll or follower roll.

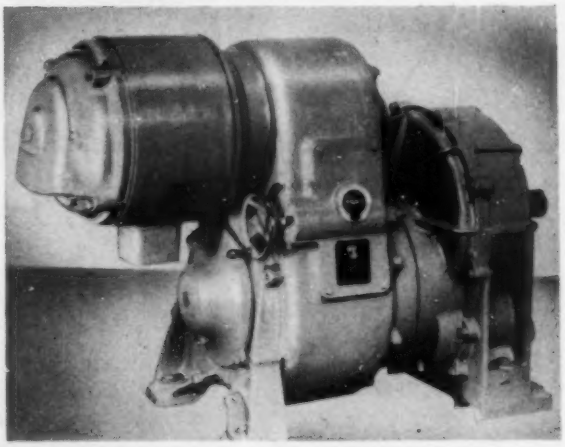
Reeves Pulley Co., Columbus, Ind.

Heavy-Duty Variable Speed Drive Unit

With speed variation of 2:1, 3:1, and 4:1, new double reduction, 20 and 25 hp heavy-duty variable speed drive units have self-contained heavy duty electric power drives providing infinite variable speed in the low ranges.

The 20 hp type 364 KFEB is available with maximum speeds ranging from 176 rpm to 42 rpm and the 25 hp type 365 KFEB with maximum speeds ranging from 176 rpm to 64 rpm. Maintenance of any selected speed is made possible by means of positively adjusted variable pitch pulleys. The totally enclosed, fan-cooled model has a dual cooling system for internal and external cooling. In this model, air inside the motor is circulated through air passages between the motor housing and stator, over the motor windings, and through openings in the motor. Much of the heat is carried off by a continuous flow of cooling air forced over the motor housing by an external fan and removable grilled fan cover.

Sterling Electric Motors, Inc.,
5401 Anaheim-Telegraph Rd., Los Angeles, Calif.



USED AS PRESSURE BALANCING VALVES, light-weight accurate, low-pressure relief and vent valves prevent over pressuring and under-pressuring of containers holding sensitive equipment. Holds pressure below the valve opening pressure, with zero leakage, indefinitely. James-Pond-Clark, 2181 Foothill Blvd., Pasadena 8, Calif.

A NON-INFLAMMABLE PLASTIC CABLE CLAMP made of Saran, is pliable, can be opened to any dimensions, and remains stable when exposed to mild acids, chemicals, and oils. Having good electrical properties, and not affected by immersion in water, the clamps range in size from ⅛ to 1¼ inches. Holub Industries, Inc., Sycamore, Ill.

SAID TO BE THE SMALLEST PULSE TRANSFORMER, the model MPT 101-0.1 has 0.1 microsecond pulse widths and rise times of less than 0.005 millimicroseconds. Weighs less than 0.03 oz., and will operate at temperatures ranging from —70 C to +125 C. PCA Electronics, Inc., 6368 De Longpre Ave., Hollywood 28, Calif.

CONTINUED ON PAGE 236

It's welded... but you can't feel the weld

• A special tool removes any exterior weld flash from electric-welded steel tubing immediately after welding . . . thus the *eye-appeal* of products like tubular steel furniture. If required, the inside can be similarly finished, meeting the *functional* requirements of products like pneumatic tube systems.

Investigate the economy and physical advantages of Brainard welded steel tubing for *your* products. Write Brainard Steel Division, **Dpt. GG-3,** Griswold Street, Warren, Ohio. An integrated producer; offices throughout the U. S.

Brainard
SHARONSTEEL
STEEL DIVISION
SHARON STEEL CORPORATION

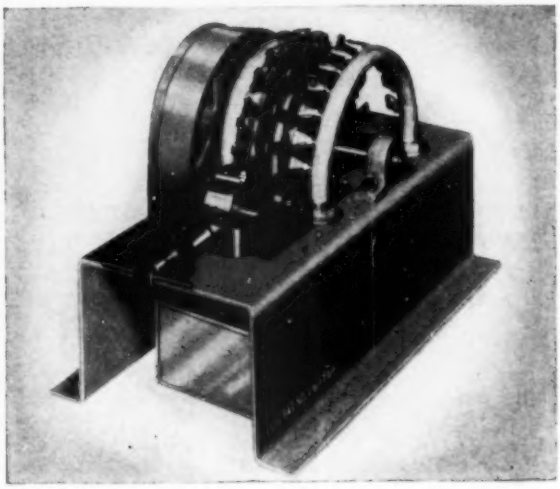
WELDED STEEL TUBING

Tests Resistance of Steels to Heat Checking

Because many parts used at high temperatures, such as the parts of automotive, aircraft, and other internal combustion engines, fail under thermal stresses or heat checks, a new device called the Thermo-Test was developed to determine the relative resistance of different materials to heat checking. In the test, pieces are successively heated, stressed and cooled. This cycle is repeated until the specimen develops visible cracks or heat checks.

The number of cycles required to produce heat checks are indicated on a counter attached to the machine. As many as eighteen test pieces can be tested at one time. The effects of various heat treatments, the range of heating and cooling, amount of pressure applied to the specimen and the effects of various alloying elements on the resistance of steel to heat checking can be studied. Various materials used for molds, permanent molds, die casting dies, glass molding dies, drop forging dies, hot piercing mandrels, extrusion dies, hot rolls, can be tested. The test unit measures approx. 24 in. wide 36 in. long and 18 in high.

H. G. Keshian Co., Hotchkiss Grove, Branford, Conn.



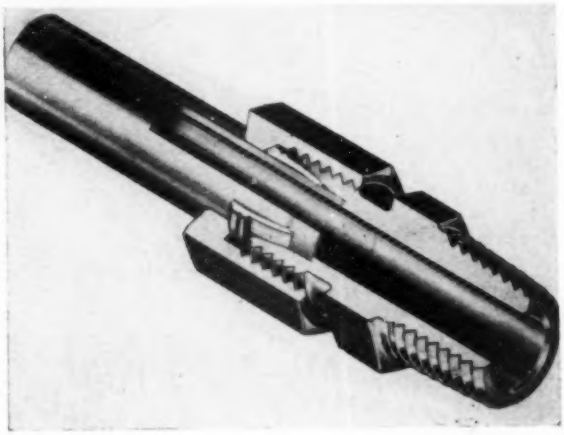
Tube Fitting Requires No Special Preparation

Said to provide a more positive seal than flared or compression type fittings, a new tube fitting requires no flaring, threading, welding, or soldering, nor does it require special preparation or tools to complete the installation.

The tube fitting consists of a sleeve, nut, and tapered body. As the nut is tightened, it forces the sleeve forward into the taper of the body. The leading edge of the sleeve contracts, forcing the cutting edge to shear a slight groove into the outer surface of the tubing, providing a leak-proof joint between the fitting and the tube. The nut pressing on the bevel of the sleeve gives a tight grip on the tube.

When fully tightened, the sleeve is bowed slightly at the mid-section, causing it to act as a lock-washer. This locking action maintains constant tension between the body and nut, preventing loosening of the nut. Once the fitting has been assembled, the sleeve becomes permanently attached to the tube. Disassembly and reassembly of the fitting can be made without any loss of the sealing quality.

The fittings are available in carbon and stainless steels from distributors, and in monel and brass on special order.



The Weatherhead Co., 300 E. 131 St., Cleveland 8, Ohio

DESIGNED FOR PORTABILITY and a high degree of accuracy, a new combination temperature indicating pyrometer and millivoltmeter has thermocouple leads to permit temperature checkings up to 8 ft. from the instrument. Three scale ranges are available, all calibrated in Fahrenheit, Centigrade and Millivolts: 800 F., 430 C., 17 MV.; 1600 F., 865 C., 36 MV.; 2250 F., 1225 C., 50 MV. Automatic compensation for internal resistance changes due to variation in temperature is provided. Accuracy is within one percent. Thermo Electric Mfg. Co., 480 Huff St., Dubuque, Iowa.

HY-TIN, a paste containing powdered solder suspended in a powerful scavenger action flux, cleans and tins in the same application: cast iron, stainless steel, monel, cast steel, copper brass, galvanized and lead coated steel. The flux is stable and non-active at normal temperature, but at soldering temperature it turns liquid and is powerful enough to remove the scale and tin black iron. There is no metal and flux separation which require mixing and there is no sputtering when applied to heated metal. It does not dry and cake. Farrelloy Co., 1241 N. 26th St., Philadelphia 21, Pa.

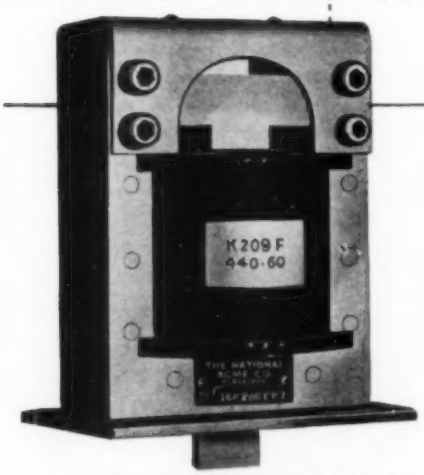
CONTINUED ON PAGE 238

doing a job automatically?

BY REMOTE CONTROL?

IN CRAMPED QUARTERS?

actuate clutches	print symbols	operate valves
operate switches	operate safety devices	vibrate cutting knives
control machines	eject work in process	open and close doors
move levers	actuate clamping	open and close hoppers
	hold chucks	sort inspected parts



SADDLE STOP LIMITS PLUNGER RETURN

A leather faced saddle type retainer stop is available for all standard series Namco push type solenoids. This plunger retainer acts as a positive stop to gauge the length of stroke, also as a cushion to reduce noise and absorb impact forces when the plunger is subjected to a severe return blow.

Like More Details?

Engineering Bulletin No. EM-52 shows many standard and special Namco solenoid applications, also dimensions, types of mountings, ratings and other useful data. Ask for your copy.

then you need NAMCO "STELLITE"-WELDED Solenoids

Solenoids offer you a modern, up-to-date way of doing jobs automatically—by remote control, even in cramped quarters.

With the positive, accurate action of Solenoids you can simplify design, manufacture and operation. They're taking the place of expensive, bulky gear trains, levers, linkages and other mechanisms. Many a manufacturer with a cost or space problem, has found the solution in Namco Solenoids.

Namco Solenoids with "Stellite"-Welded contacts, are compact, rugged and reliable. We'll be glad to recommend the size and style best suited to your job—with standard or special terminal blocks and mountings.

Namco "Stellite"-Welded Solenoids are built in sizes with ratings from 2½ to 25 pounds, push or pull, at 1" stroke; combination push-pull and other special applications are available. Either AC or DC type may be specified.

ELECTRICAL MANUFACTURING DIVISION

The NATIONAL ACME CO.

170 EAST 131st STREET • CLEVELAND 8, OHIO

ACME-GRIDLEY BAR AND CHUCKING AUTOMATICS (1-4-6 AND 8 SPINDLE) • HYDRAULIC THREAD ROLLING MACHINES • AUTOMATIC THREADING DIES AND TAPS • LIMIT, MOTOR STARTER AND CONTROL STATION SWITCHES • SOLENOIDS • CONTRACT MANUFACTURING

Computer For Centralized Production Control

Known as the Off-Schedule Production computer, a device for centralized production control, the O S P computer continuously takes into account the elapsed time, preset time per scheduled occurrence, and the actual occurrence to indicate directly any deviation from a pre-set schedule. The occurrence can be any quantity that can be translated into an electrical impulse of 0.05 sec. duration. In this particular application, the occurrence is a unit of production.

A unit multiplier is used to provide flexibility in selecting what the deviation unit graduation on the dial shall indicate. For example, when a unit of production is scheduled to be produced every ten seconds and it is desirable to make each deviation unit graduation on the dial equal to six actual production units or one minute time, the unit multiplier is turned to factor 6. The multiplier which has a standard range of 1 to 10-15-25, is of value where the unit of production per unit time is relatively small, and provides flexibility in determining the quantitative value of the scale graduations.

To supplement the indicating dial with its "Behind Schedule" and "Ahead of Schedule" graduations, a white, green, amber and red indicating light is used along with a warning buzzer that comes on when any pre-determined critical deviation point has been reached.

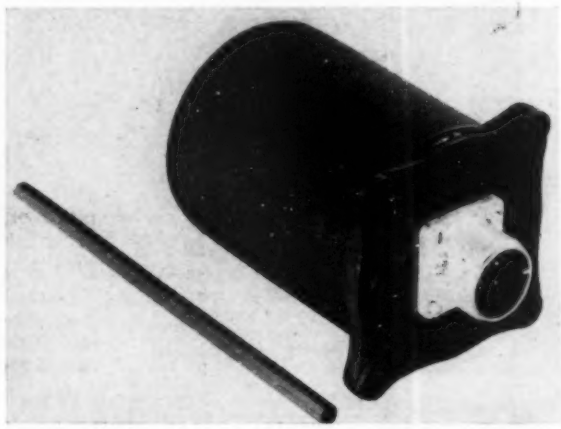
The O S P computer case measures 7½ in. wide, 7¾ in. high, and 8 in. deep, and weighs 9 pounds. A counter-type time dial simplifies the unit time setting which has a range of 5 seconds to 5 minutes 20 seconds. A counter is also included so that the actual production count is visible at all times. The computer is automatically reset by a momentary reset switch. Operation is on 110 v a-c, 60 cycles, with a power consumption of 7 watts.

Industrial Computer Corp., 272 Lembeck Ave., Jersey City, N. J.

Oil-Filled Accelerometer Unit

Compactly designed to fit in an oil-filled case, a new accelerometer, model 24133 is resistant to vibration and has long-life expectancy. It utilizes a potentiometer resistance with a large output, requiring no amplifying unit in most cases. Low, natural frequency is an additional feature. Instrument ranges may be obtained up to 30G while standard resistance ranges are 2,000 or 5,000 ohms. Special adaptations of the unit are available. The potentiometer element safely carries current up to 15 milliamperes. The new accelerometer has good resolution with 0.25 percent minimum offered on the standard instrument.

The model 24133 is a 1 percent instrument in performance. It is designed to operate in temperatures between —54 C. and 71 C. Damping is 0.5 ± 0.075 of critical for a 7.5G instrument. It is designed for applications in computing, telemetering and aircraft missile control.



G. M. Giannini & Co., Inc., Bin-N, Pasadena 1, Calif.

DESIGNED ESPECIALLY FOR AIRBORNE ELECTRONIC EQUIPMENT, a new, hermetically sealed relay meets joint Air Corp and Navy specification ANE-19. Small, and light in weight, it is particularly adaptable for applications in miniaturization. The relay will withstand 10 G's vibration with a minimum available power of 500 milliwatts. Coil resistances up to 16,000 ohms. Relays come either in SPDT or DPDT with contacts either silver rated at 1½ amps or palladium at 3 amps. Advance Electric & Relay Co., 2435 N. Naomi St., Burbank, Cal.

CONTINUED ON PAGE 240

NEW CATALOGS AND BULLETINS

A Reader Service To Help Keep You Up-to-Date

(1) MAGNETIC AMPLIFIERS — Karl-Douglas Associates. Booklet, 4 pp. Describes six advantages of magnetic amplifiers over other power control amplifier devices; lists typical performance specifications for 60 cycle and 400 cycle units; and lists the various applications where they can be used.

(2) SOLENOIDS, COILS, TRANSFORMERS—Dormeyer Industries. Catalog 20, 20 pp. Illustrates various sized solenoids, with engineering drawings and performance curves of each. Lists applications. Illustrates a variety of coils, with paper section, form wound, and bobbin wound types available. Transformers range in size from one V.A. to 3 K.V.A. for every purpose.

(3) ELECTRONIC INSTRUMENTATION—Berkeley Scientific Div. Booklet, 32 pp. Contains a description of electronic instruments providing direct-reading digital presentation of information, and their principal industrial applications. Covers high-speed counting, counting plus control, precise interval timing, rpm measurement, pressure, temperature, flow, frequency, and others.

(4) MOTORS AND HYDRAULIC ACTUATORS—Jack and Heintz, Inc. Bulletin 1351. Describes rotomotive equipment for standard and custom aircraft electric motors and electric and hydraulic actuators. Data on product features and performance are given for small high-speed motors, submersible fuel boosters, refueling pump motors, and specially designed actuators.

(5) PUMP INSTALLATION — Viking Pump Co. Bulletin TS-3, 8 pp. Covering the problems of the pump installation, it contains information particularly applicable to the rotary pump. Has definitions and illustrations of types of head; discusses viscosity and types of liquids; pipe friction; suction lifts; horsepower; and materials. Has charts, curves, and diagrams.

(6) CERAMIC COATING FACTS—Ryan-Cameo Co. Booklet, 10 pp. Tells what high temperature ceramics are; what properties they have; use in aircraft; what metals may be coated. Has illustrations of production, testing, facilities, and other data on the ceramic coating of metals.

(7) CENTRAL HYDRAULIC SYSTEMS—Greer Hydraulics, Inc. Bulletin 900, 8 pp. Shows how to get more dependable, economical, and flexible central hydraulic systems. Describes and illustrates compression molding press systems, and compares weight-loaded and hydro-pneumatic accumulation systems. Has schematic diagrams for hookups for various conditions, and methods of calculation of accumulator capacity.

(8) MOTOR SELECTOR SLIDE RULE—Howard Industries, Inc. A pocket-sized device, it has detailed information on 35 EMC and Cyclohm fractional motors in ratings from 1/2000 to ½ hp. Gives: motor type; hp continuous and intermittant; full load rpm; full load amps; full load efficiency; core size; winding type; voltage. For cyclohm motors it gives: frame type; poles; speed; hp; pull-in, pull-out, and starting torque.

(9) INDUSTRY RELAYS — Automatic Electric Co. Circular 1702-A, 12 pp. Has illustrations and complete specifications for a complete line of telephone-type relays, including hermetically sealed (in metal and glass containers) sub-miniature, and plug-in types.

(10) RECORDERS AND INDICATORS—Minneapolis-Honeywell Regulator Co. Catalog 1520, 45 pp. Contains information on the Electronik non-control precision instruments for measuring temperature, pressure, flow, pH, and other variables. Has detailed specifications for each model. Has many illustrations showing construction, installation, and application of the various types of precision instruments.

(11) MAGAMP REGULATOR—Westinghouse Electric Corp. Booklet B-5468, 19 pp. Discusses the use of these regulators for various control problems in steel mills. Used for amplifying voltage and current, it consists of an iron core, with an a-c output winding and one or more d-c control windings. Also discusses all characteristics of the regulator. Has many illustrations.

(12) PRINTED CIRCUITS—The Kotula Co. Booklet, 8 pp. Printed circuits, their function, fabrication, and application are covered. Has materials, electrical characteristics with tables of valves, components such as capacitors, resistors, tube sockets, and switches. Assembly methods are described.

(13) TESTING MACHINE ACCESSORIES—Tinius Olsen Testing Machine Co. Catalog 46, 22 pp. Has detailed information on instrumentation, tools and accessories. Points covered are: electronic recorders; electronic strain instrumentation; mechanical extensometers; tension, compression, transverse, shear, bend, and hardness tools; electronic load cells; and other devices. Has illustrations of each.

(14) DYNAMIC BALANCER — International Research and Development Corp. Booklet, 4 pp. Describes and illustrates the vibratron, an instrument for vibration analysis and dynamic balancing. Illustrates applications, and discusses its use in: production; inspection; maintenance; research; detection; and testing.

(15) COPPER-BASE ALLOY ROD—Copper and Brass Research Association. Handbook, 30 pp. Discusses the advantage of using copper-base alloys; forms and tempers; table of mechanical properties; complete details on machining; supplementary or secondary operations; and assembly operations. Has illustrations on each topic plus many tables.

(16) DIAL THEROMETER—Marsh Instrument Co. Catalog 76-T, 30 pp. Gives

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Reader Service Manager
Product Engineering
330 West 42nd Street
New York 36, N. Y.

complete specifications, line drawings, templates and dimensional charts for each individual dial size type. Discusses movement and construction of each.

(17) ROLLER BEARINGS—Berliss Bearing Co. Catalog 522, 16 pp. Contains a complete description of, and specifications for the bearing selection for the materials handling, automotive, agricultural machinery, and transportation industries. Covers rollers, bearings, roller assemblies, cage and split outer race assemblies, plus bearing selection data covering load speed factor, bearing life, and shaft factor.

(18) LUBRICATION SYSTEMS—Trabon Engineering Corp. Bulletin 529, 4 pp. Includes engineering description of technical methods of operation of reversible and manifold types of lubrication systems for oil and grease. Line drawings show possible installation.

(19) AIR CYLINDERS—Lindberg Engineering Co. Bulletin 731, 16 pp. Diagrams, charts, and photographs explain the capacity, type of mounting, and a list of engineering features. Complete specifications for seven types of mountings of air cylinders, and other components.

((20) LOCK NUTS—The Palnut Co. Bulletin 577, 8 pp. Describes lock nuts for heavy assemblies and severe vibration. Outlines locking principle, advantages, applications, assembly methods, sizes, materials, finishes and other engineering data.

(21) INJECTION MOLDED RUBBER—Minnesota Rubber and Gasket Co. Booklets, 20 pp. Discusses the injection molding of all types of rubber parts; gives the characteristics of synthetic rubbers, and o-rings for use with pressures up to 3000 psi. Also gives possible uses for injection molded silicone rubber products.

(22) RUBBER-TO-METAL PARTS — Acushnet Process Co. Booklet, Supplement A, 8 pp. The process of rubber-to-metal adhesion is discussed giving: applications, procedures, design; compounding; processes; and bond strength ratings. Parts are illustrated showing: shock mounts; vibration isolators; shaft seals; valve seats; rolls; and pulleys.

(23) MULTI-CIRCUIT FLOAT CONTROLS—Automatic Control Co. Bulletin 3500, 4 pp. Covers the type M units used for water, sewage, irrigation, and flood control systems. One float can provide a coordinated operation of 2 to 18 or more pumps or valves. Gives operating schedule, range of units, and installation plans.

(24) FLEXIBLE CORD—Whitney Blake Co. Bulletin FC-52, 24 pp. Includes all of the new Underwriters' classifications for flexible cords made by this company. Features data on Dynaprene and rubber jacketed cords, and braid covered types. Also information on cord selection, and technical data on wire and cable.

(25) UNIVERSAL JOINTS—The Apex Machine and Tool Co. Catalog 27, 24 pp. Covering a complete line of universal joints for aircraft and industrial applications, the catalog contains application data sheets, specifications and other information. Models described are: heavy-duty and light-duty aircraft joints; heavy-duty industrial, and quick-change universal joints.

(26) ELECTRIC POWER CONTROLS—Cutler-Hammer Inc. Booklet M-78A, 80 pp. Many illustrations and complete information on: magnetic brakes, clutches and separators; d-c and a-c manual starters and regulators and drum controls; rheostats; resistors; a-c magnetic squirrel cage controls; a-c and d-c accessories; and other components.

(27) GEARMOTORS — Star-Kimble Div. Bulletin B-601, 8 pp. Data on a line of a-c and d-c gearmotors with ratios from 2.5:1 to 97:1, and ½ to 75 hp. Gearings are planetary, offset or right-angle worm-wheel, and single and double-reduction. Illustrations of all types.

(28) OILLESS BEARINGS—Arguto Oilless Bearing Co. Catalog 210, 20 pp. Points on screw conveyor bearings, conveyor roll bearings, installation instructions, list of standard sizes, engineering information, and other specifications. Has illustrations, curves, and tables.

(29) INSTRUMENT TRANSFORMERS—General Electric Co., Bulletin GET-1366A, 16 pp. Titled, "Instrument Transformer Accuracy Standards," it aids in the selection of proper instrument transformers for any particular application. Lists accuracy standards for potential, metering current, and relaying current transformers. Shows graphical equivalents of Amer. Standards Association accuracy classes.

(30) SWING JOINTS—Barco Mfg. Co., Catalog 400, 8 pp. Has illustrations, line drawings, and specifications for single and double swing joints for oils, gasoline, water, air, gas, and chemicals. Schematic diagrams show typical loading and unloading line applications.

(31) NUTS—Grip Nut Co., Booklet, 8 pp. Complete specifications on: the hi-nut; pliot weld nut; clinch nut; countersunk weld nut; a semi-finished nut, steel or brass; and a lock nut. Has illustrations and engineering drawings.

(32) ELECTRIC MOTORS—Doerr Electric Corp., Bulletin 100, 4 pp. Data on standard and special application designs from 1/30 to 5 hp in base mounted and face mounted frames. Applications include: pumps, brakes; power tool; hoist; and fan, plus motor parts for built-in drives.

(33) EDDY-CURRENT EQUIPMENT — Dynamatic Corp. Bulletin GBI, 16 pp. Discusses basic principles of eddy current machinery. Curves show torque and heat characteristics. Other sections devoted to cooling, efficiency, control, operating characteristics, and other units made by the manufacturer. Large illustrations are included.

(34) FLEXIBLE METAL HOSE—Flexonics Corp. Catalog CMH-128, 16 pp. Specifications and other data for the new expansion joints having increased traverse per corrugation. Also gives specifications and application information for corrugated and convoluted types of flexible metal hose, including couplings, flanges, nipples, and assemblies. Has large cross sectional illustrations.

(35) ACTUATORS—Phillips Control Corp. Bulletin 6, 8 pp. Discusses a line of actuators for industrial and commercial use for a-c or d-c operation. Has engineering diagrams, specifications, and many comparative pull charts and volt-ampere curves.

(36) GEAR REDUCERS—D. O. James Gear Mfg. Co. Catalog 47-B, 88 pp. Aids for selecting the proper gear reducer for specific power transmission problems. Divided into: (1) motorized gear speed reducers, a combination of motor and reducer; (2) motor reducers, assembled on base plate with a coupling; (3) gear speed reducers. The gear reducers are available in 35 sizes in ranges from ¾ to 75 hp with ratios of 1.2:1 to 1300:1.

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Contact KAYDON of Muskegon

FOR ALL TYPES OF BALL AND ROLLER BEARINGS: 4" BORE TO 120" OUTSIDE DIAMETER

Photo by courtesy of Chrysler Delaware Tank Plant

So big! This super-precision turret bearing is so big that these four beauties stood comfortably inside only a portion of the 7-foot diameter to have their picture taken. • KAYDON also created the initial pilot-bearings (28.333" I.D. x 33.375" O.D. x 2.875" section) for cupolas of Patton T-48's. • *Both sizes of bearings were uniquely engineered with internal gears cut integral with the inner race.*

• • •

In many types of heavy-duty industrial machinery and war equipment, unusual KAYDON Bearings have been designed to make tough jobs easier, with dependable, controlled precision.

Dependable KAYDON BEARINGS in world's greatest tank!

Some details of performance of the new Patton T-48 tank may remain closely guarded secrets, but now it can be told that KAYDON created the initial pilot-bearings for its gunmounts and cupola.

More than merely a masterpiece in tank engineering, the Patton 48 is also an outstanding economic achievement... Army's most economically produced tank... resulting from fine teamwork of industry and labor.

Today, manufacturers of tanks... guided by KAYDON... are also producing these big super-precision bearings. Vital precision facilities thus are multiplied to speed production.

The Patton 48... speedy, most mobile of all tanks... is a symbol of insurance for peace through strength! Manufacturers contributing to this achievement take pride in confidence that America's industrial brains and skill, mobilized in a democracy, can meet any challenge! The Patton 48's are here... and they came fast!

We'll be glad to work with you on difficult bearing problems.

THE KAYDON ENGINEERING CORP.

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust
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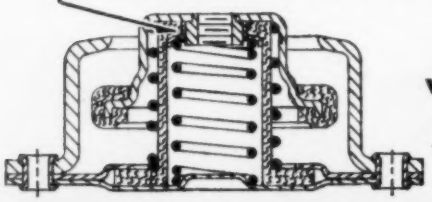
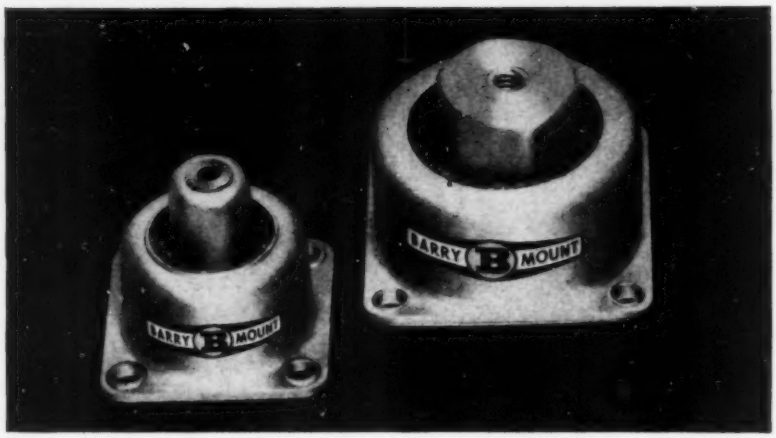
PRECISION BALL AND ROLLER BEARINGS

SHOCK AND VIBRATION NEWS

HERE'S THE SECRET



... of a NEW wire-mesh isolator that won't change on the job!



The new Type 7630 and Type 7640 ALL-METL Barrymounts have been specifically designed to eliminate loss of efficiency due to damper packing. Previous wire-mesh unit vibration isolators exhibited a definite loss of damping efficiency after a period in actual service, because the wire-mesh damper tended to pack. These new unit Barrymounts have eliminated this difficulty, because the load-bearing spring returns the damper to its normal position on every cycle.

- Very light weight — helps you reduce the weight of mounted equipment.
- Hex top — simplifies your installation problems.
- High isolation efficiency — meets latest government specifications (JAN-C-172A, etc.) — gives your equipment maximum protection.
- Ruggedized — to meet the shock-test requirements of military specifications.
- Operates over a wide range of temperatures — ideal for guided-missile or jet installations.

Compare these unit isolators with any others — by making your own tests, or on the basis of full details contained in Barry Product Bulletin 531. Your free copy will be mailed on request.

See these new isolators in action, and discuss their applications with us, at the New York I.R.E. Show.

THE BARRY CORP.

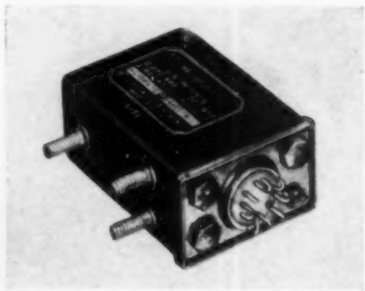
730 PLEASANT ST., WATERTOWN 72, MASSACHUSETTS

SALES REPRESENTATIVES IN
Atlanta Baltimore Chicago Cleveland Dallas Dayton Detroit Los Angeles Minneapolis New York
Philadelphia Phoenix Rochester St. Louis San Francisco Seattle Toronto Washington

New Miniature Enclosed Relay

Bantam-sized class "S" relays are now available in a new small hermetically sealed enclosure with the entire unit measuring $2\frac{1}{32}$ in. x $\frac{31}{32}$ in. x $1\frac{1}{2}$ in. and weighing only $1\frac{7}{8}$ ounces. Mounting studs may be arranged on base or narrow side of housing.

This miniature relay was designed



for minimum inductance and maximum make-and-break speeds. It is tamper-proof and atmosphere-protected and meets provisions of MIL-R 6106. This relay in its new enclosure has applications wherever there are extremes of shock, temperature and vibration.

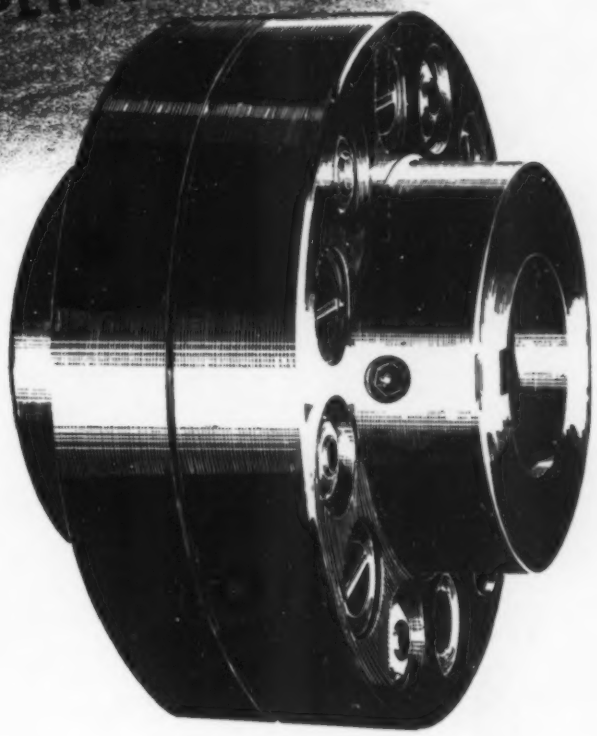
Automatic Electric Sales Corp.,
1033 *W. Van Buren St., Chicago, Ill.*

Single and Dual System Float Switch

Originally designed as an aircraft high-level fuel control instrument, giving automatic cut-off control for single point, high pressure fueling and air to air refueling, a new float switch may be used for fluid level control in industrial applications. A light-weight unit, it is available in different sizes, some of which include relays to handle heavy electrical load; others are designed for complete submersion in fluids.

The float switches can be supplied

WHEN DESIGN ENGINEERS THINK OF RUBBER BUSHED FLEXIBLE COUPLINGS



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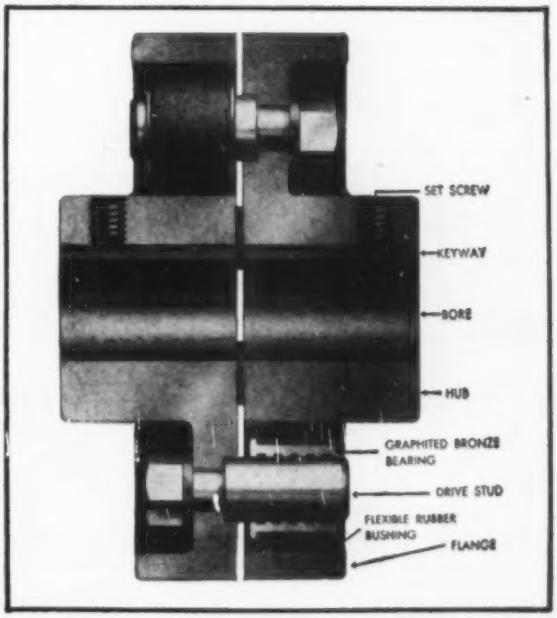
AJAX

as America's standard



• 30 Years of satisfactory performance on direct-connected generators, pumps, compressors, winches, speed reducers and other similar equipment have proved the economy of protecting good machinery with Ajax Flexible Couplings.

They protect bearings, gears, armatures, impellers and other costly working parts against unavoidable angular and offset misalignment.

Ajax Flexible Rubber Bushings provide a quiet, cushioned drive in both directions of rotation.

Ajax oilless bronze bearings are self-lubricated for life.

No problems are set up by centrifugal force. They operate successfully in abrasive-laden air. They operate vertically or horizontally.

Free end float lets electrical machinery find its magnetic center without interference.

Standard Ajax Couplings are made of forged steel or cast semi-steel. Aluminum, bronze and other metals available for special applications. Made in a wide range of sizes and capacities...write for catalog.

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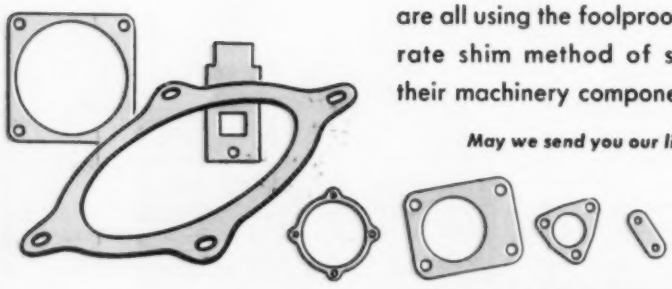
WESTFIELD, NEW YORK

These famous companies are all using the foolproof, accurate shim method of spacing their machinery components.

May we send you our literature?



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with single level or dual level systems. Each system has an electrical signal through a magnetically operated switch, which is hermetically sealed in a glass tube. The actuating alnico magnet is in the counter weight of a statically balanced float assembly. The actuating magnet, positioned by the float, opens or closes the switch at predetermined levels which are set at the factory.

Both single and dual float switches can be provided with levels set at any distance between 1 and 18 inches from the mounting flange.

Revere Corp. of America, Wallingford, Conn.

Portable pH Meter

Powered by 3 radio batteries, giving 2000 hours of service, a portable pH meter has a 5½ in. scale with 1 mm per 0.1 pH division, and is readable to 0.02 pH. Readings from 0 to 14 on a single scale that is continuous through a neutral point.

The unit is self-contained, and is applicable for laboratory, plant and field use, including grounded tanks. A carrying frame holds the instrument, breaker, buffer, and wash bottle.

Millivolt scales: —400 to +400; also —800 to +800 for use with an external voltage divider. The unit has a temperature control from 0-100 C. A stabilized power supply unit is available for alternative operation from 100-125 V a-c.

Photovolt Corp., 95 Madison Ave., New York, N. Y.

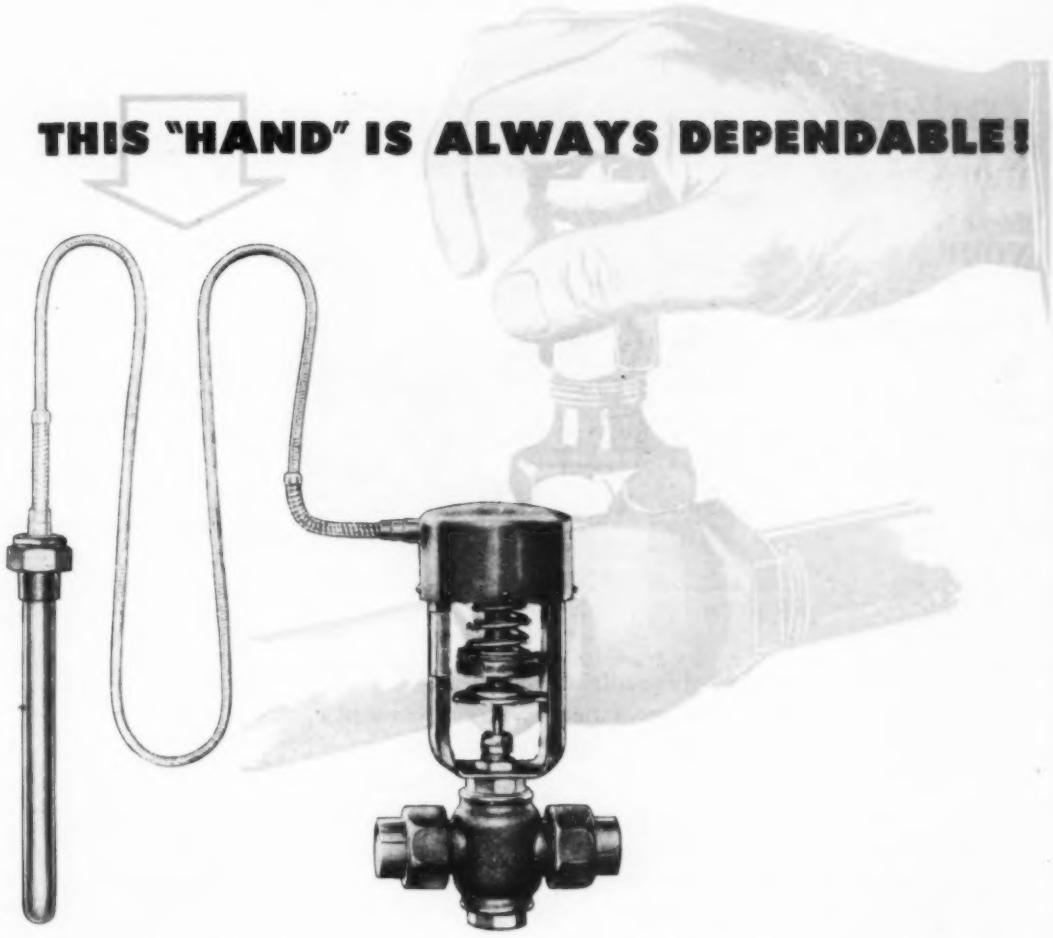
Humidity Indicator For Small Packages

Designed for use in the dehydrated packaging of military materials and other products which must be kept in storage safe from moisture damage, a new type of humidity indicator known as a "bull's-eye", is intended to be assembled as an integral part of the container itself.

The new device is equipped with gaskets and metal fittings which per-

SYLPHON CONTROLS FOR DEPENDABILITY

THIS "HAND" IS ALWAYS DEPENDABLE!



Make it "Standard" for your equipment... assure accurate temperature control

● Automatic Sylphon Controls, installed as standard equipment, do a better job, any time, than hand-operated valves or "guess methods" do at governing temperatures. They assure your equipments' best performance . . . save trouble for you and your customers . . . give you an extra sales advantage.

See why! Hour after hour, they maintain temperature that assures *uniform* processing conditions . . . *constant* product quality. They help reduce spoilage, wasteful overheating . . . save manpower and manhours.

Sylphon Temperature Regulator No. 999, pictured here, is one of the Sylphon line. Its outstanding features include stainless steel frame for minimum heat conduction from valve to regulator head . . . large size 2-ply Sylphon bellows for added power . . . less height and weight than other types. Self-operating—requires no auxiliary power source. Particularly suited for storage water heaters, metal plating tanks, bottle washers, treaters, slashers, etc.

Find out about the advantages of No. 999, or of other Sylphon Temperature Regulators, as standard equipment to help *your* machines operate better, longer, more economically. Write for Catalog EP-A.

Temperature Controls • Bellows Devices • Bellows Assemblies

FULTON SYLPHON DIVISION

FIRST WITH BELLOWS

ROBERTSHAW-FULTON CONTROLS CO., KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal

is

coil-itis* increasing your temperature problem?

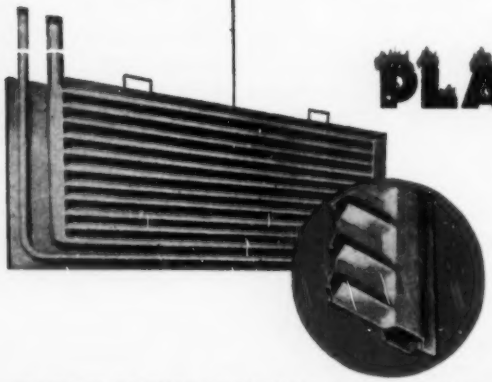
Here is a new treatment for solving your heat transfer problems that is as revolutionary as a new wonder drug. It stops coil-itis* cold . . . It eliminates the many troubles that have plagued industrial heating and cooling practices due to the use of old-fashioned, outmoded pipe coils. This revolutionary new unit, called a Platecoil, heats or cools 50% faster and takes 50% less space in the tank. It simplifies maintenance and saves hours of downtime.

Write for bulletin P77 today!

PLATECOILS SAVE 50% IN HEAT TRANSFER COSTS

PLATECOILS COOL QUENCH OIL TANK FOR ⅓ THE COST

At the K-D Manufacturing Company, Platecoils are proving more efficient, yet cost only 1/3 as much to install. Ask about other case histories.



PLATECOIL

REPLACES PIPE COILS

Coil-itis — Diagnosed as tank heating and cooling problems. Platecoils — the prescription for solving pipe coil problems.

PLATECOIL DIVISION, KOLD-HOLD MANUFACTURING CO., LANSING 4, MICHIGAN

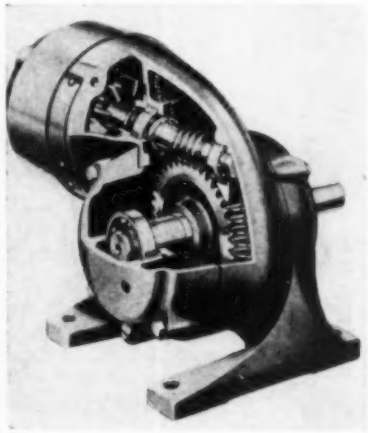
mit it to be fastened to a nipple welded to the shell of the container, or package, providing a tight seal against moisture infiltration. The bull's eye is of glass and contains Tel-Tale indicating silica gel, a product which changes color from deep blue to light pink as it picks up moisture. The air within the container can circulate freely through the indicating gel.

The indicating "bull's-eye", although now used in large containers, can also be used with small packages such as individual spark plug containers.

Davison Chemical Corp., Baltimore, Md.

Low-Speed Right Angle Worm-Gear Motors

Introduced as the type GW Synchro-gear, a new line of low speed right-angle worm-gear motors uses a cantilever design to protect the gear alignment. The unit has splash lubrication, a hardened and ground worm, leakproof oil seal, and asbestos pro-



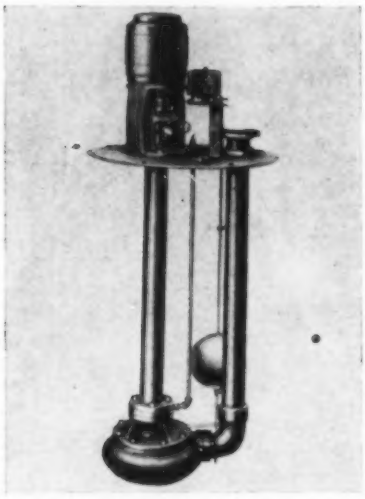
tected windings. It also has a self-locking brake action.

The new motor is built in speed ranges from 20 to 155 rpm and gear ratios up to 58:1. Horsepower ranges from ¼ to 3. It is made in both 3-phases and single phase. The unit can be installed horizontally or upright and can be provided with a footless flange mounting. Other modifications have variable speed, splashproof design and total enclosure.

U. S. Electrical Motors, Inc., Box 2058, Los Angeles, Cal.

Vertical Sewage Pumps

Having fluid ends in 2, 3, and 4 in. sizes, and designed to handle solids 1½, 2, and 3 in. in dia, a new line of vertical sewage pumps have capacities



ranging from 50 to 1,000 gpm against heads up to 60 feet.

Units can be furnished with electric motors up to 20 hp or equipped for steam turbine drive. Motor mounting is designed with standard NEMA type "C" flange, with adapter flanges available. A feature of the pump is the thrust bearing assembly. The coupling in the lower half of the unit fits into the bore of a large capacity, angular contact radial and thrust ball bearing. This assembly is mounted on the end of the pump shaft directly under the adjusting nut.

The impeller is an enclosed, 2-vane, non-clog type, adjustable vertically with shaft. It is mounted on the shaft with a locking taper, woodruff key and safety lock nut. Wearing rings snub any shock on the impeller and prolong the life of the pump.

The Deming Co., Salem, Ohio

Miniature Welding Assembly

Called the "tweezer-type" spot-welder, this small unit is said to have produced satisfactory results in welding two 0.0008 in. dia. copper or nichrome wire, or two 0.018 in. sheets of type 302 stainless steel. Using a special electrical circuit, the welds are uniform, burn-free, and spatter-free; with the electrode-switch assembly pro-

✓ check the price

✓ check the analysis

✓ check the performance

and you'll specify

MUELLER BRASS CO.

tuf-stuf®

aluminum bronze

check the price—TUF-STUF, the Mueller Brass Co. series of aluminum bronze alloys, can be supplied at prices below those of similar alloys. Whether you buy TUF-STUF in rod shapes, forgings or screw machine products you'll save money because these alloys are priced right, machine better and last longer.

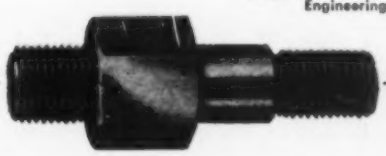
check the analysis—TUF-STUF alloys are a high copper base series containing from 9% to 13% aluminum and varying amounts of iron, nickel and manganese. They do not contain zinc and, therefore, are not subject to dezincification. TUF-STUF alloys are available in several grades with a chemical composition, suitable hardness and mechanical properties for many different applications.

check the performance—TUF-STUF alloys are light and strong—about 8% lighter than cast bronze and almost as strong as steel. They have a low coefficient of friction as well as good bearing and mechanical properties. They not only retain these properties but resist oxidation at the high speeds and high temperatures of modern production equipment. They will withstand strong acid attack or the effects of brackish waters and are highly resistant to corrosion.

These alloys can be hot-forged into relatively intricate shapes . . . need little or no machining . . . and the smooth, bright surfaces eliminate costly finishing.

MUELLER BRASS CO.

PORT HURON 17, MICHIGAN



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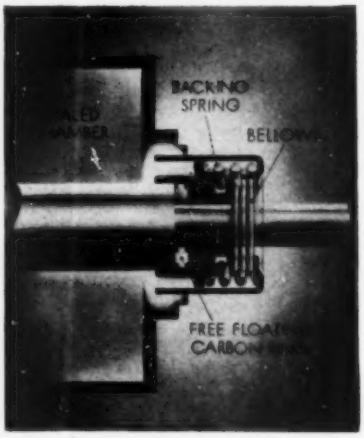
viding automatic control of the welding pressure.

The unit measures 8 in. wide by 10½ in. deep by 4½ in. high, with the electrode assembly measuring 1 in. x 2 in. x 3 in. (less electrodes). Weight is 17 pounds. Welding throat depth, 2¼ in.; welding lead length 4 feet. The welding pressure is fully adjustable, and the firing control is automatic at the pre-set welding pressure. Power consumed is 300 watts. Energy storage maximum 20 watt-sec.; minimum 0.2 watt-second.

Unitek Corp., 275 N. Halstead Ave., Pasadena 8, Calif.

Metallic Bellows Shaft Seal

An especially designed metallic bellows shaft seal suitable for sealing the control shafts of hermetically sealed equipment can be used on shafts as small as ¼ in. in diameter. It permits free turning of the shaft to accomplish movement within the sealed casing while maintaining the hermetic seal. The seal is said to be suited for



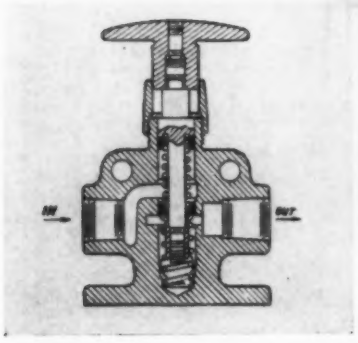
aircraft applications because of its ability to withstand large temperature changes and extremes of heat and cold. It is also unaffected by pressure changes.

Applications include: sealed electronic equipment, and industrial and military instruments. The shaft seals can be supplied to specifications.

Clifford Manufacturing Co. 121 Grove St., Waltham 54, Mass.

Air Pilot Valves Used for Remote Control

The series 3000, 3-way air pilot valves are used for remote control of 4-way pilot pressure operated air valves, and also where a small ¼ in. 3-way valve is necessary. Operating



the air pilot valve permits air to flow to the "out" port. A spring returns the valve to the original position, locking the air supply and bleeding the "out" port. This series of valves is also used with the series 5900 air pilot hydraulic valves.

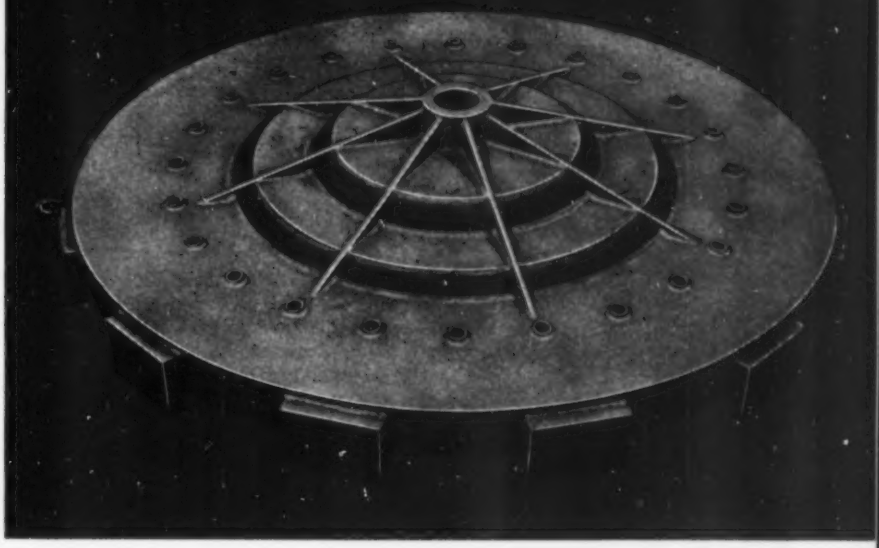
Rivett Lathe & Grinder, Inc.
Brighton 35, Boston, Mass.

Cam-Operated Toggle Valve

Large size brass and stainless steel toggle valves for controlling pressure or high vacuum systems have valve seats of semi-hard plastic material, stems sealed by synthetic rubber O-rings, and may be used at pressures ranging to 1000 psi.

Essentially the same type of valve as the smaller toggle valves made by this company, these large size toggle valves for quick opening service are now made only in ½ in. NPT female size. The principal difference is that in this series of valves, the closing action of the valve seat is provided by a hardened steel cam rather than a spring as in the smaller toggle valves. The cap nut is adjusted to such heights that when the cam handle is perpendicular to the stem, the valve seat is closed. A set screw in the cap nut locks and positions the yoke so that the cam will swing in any desired

use castings?



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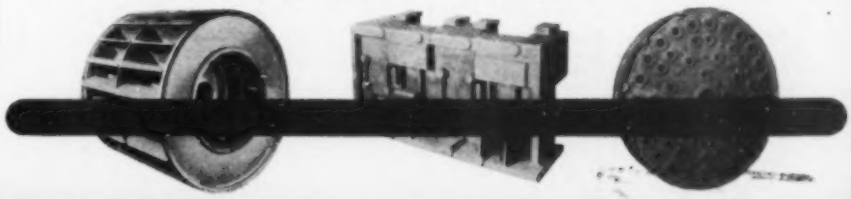

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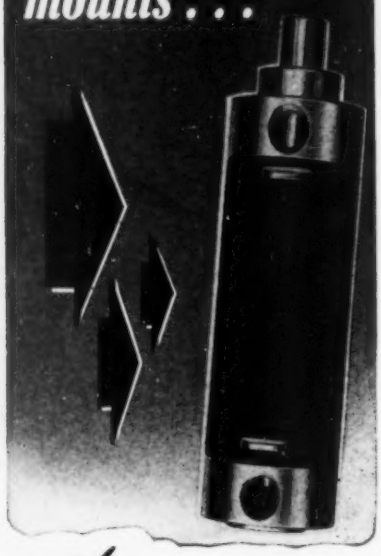

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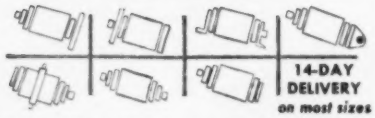

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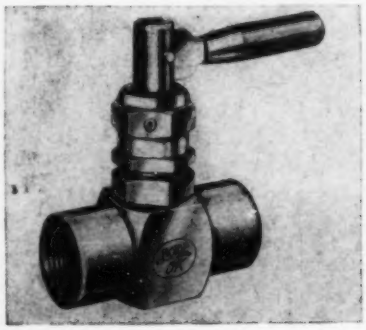


plane perpendicular to the bottom face of the valve body.

The valve can be made tight to a helium leak detector test at seat, gasket bonnet to body joint, and O-ring stem seal when the stem is not in motion. The total in-leakage past the moving O-ring stem seal during the length of time required to open or close the valve will not exceed 0.01 micron liter.

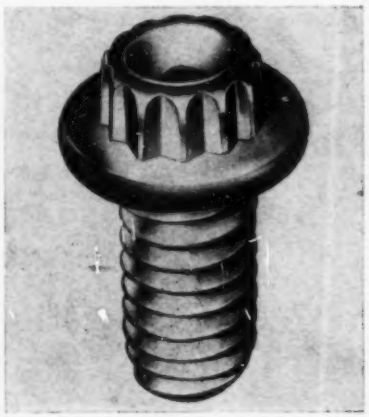
Hoke, Inc., 197 South Dean Street, Englewood, N. J.

Fasteners Permit High Torque Loads

Precision-forged, threaded 12 point aircraft type fasteners in ferrous, non-ferrous and precious metals, such as capscrews, machine screws, sheet metal screws, self tapping screws, recessed set screws, machine bolts, stove bolts, lag bolts, recessed socket bolts, automotive spring center bolts, in all standard diameters and lengths, are now being made for industrial, automotive and marine use.

These non-slip tube 12-point fasteners are specifically designed to permit higher torque loads, and will accommodate the standard 12-point socket or box type wrench.

Precision forging of the specially designed 12-point tapered head and



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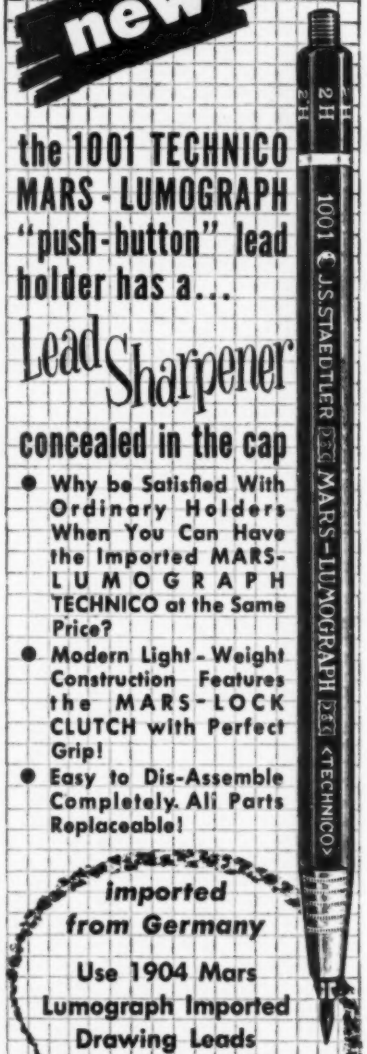

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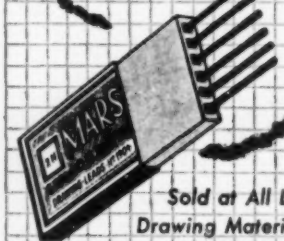

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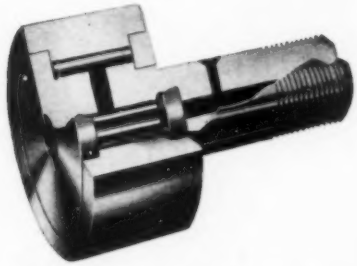
CAM ACTION IMPROVED with MULTIROL® BEARINGS

under heavier loads • with shock resistance • and space economy

Modern demands for faster, more automatic machines necessitate a new approach to cam action efficiency. Improvised bolt and roller units are no longer adequate for this mass production machine age.

Machinery manufacturers are finding that even at slow speed, it is difficult to carry the usual heavy radial and intermittent shock loads of cam application efficiently on plain bearings or standard antifriction ball and roller bearings. With increasing speeds, and lubrication limited by the desire for simplified design, the plain bearing wears excessively and fails early. Ordinary ball or radial roller bearings used on a shaft as cam followers have a



tendency to split in the outer race because of the excessive strain on the thin and superhard race sections.

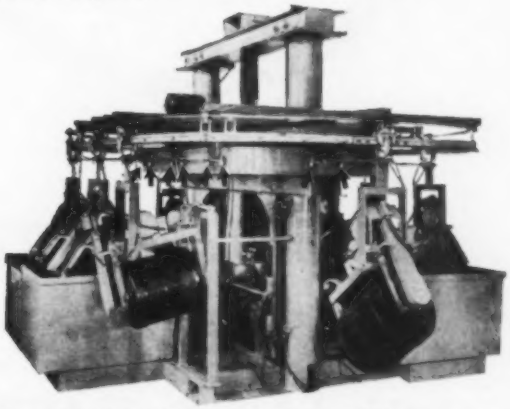
One bearing that has proven particularly successful in cam follower applications is the Multirol CF series full type roller bearing. This bearing is built especially for the repeated shock loads of typical cam action operations. The outer race section is not only heavy radially but is also martempered to combine maximum toughness with adequate surface hardness for withstanding the punishment of cam applications. The outer ring operates on a full complement of small diameter rollers so the load is evenly distributed over a greater bearing surface. The inner race and flange are made in a single piece with the stud, preventing any possibility of disassembly in operation. Greater accuracy is maintained throughout longer bearing life and, compared with plain bearings, both starting and rolling friction are reduced to a minimum. As a result internal wear is diminished and power requirements of Multirol bearing equipped machines are appreciably lessened.

Load Capacity Comparison

To illustrate the increased capacity of the Multirol CF, here is a comparison between a Multirol CF-1 bearing and a corresponding friction type roller, making use of the maximum permissable bearing pressures in pounds per square inch of projected area. The CF-1 bearing will have a maximum of 2240#, while the equivalent friction type roller would have a capacity of less than 400#.

What This Means in Terms of Performance

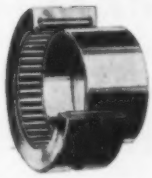
The James Hunter Machine Co., of North Adams, Massachusetts replaced units consisting of a standard roller bearing and hardened roller with Multirol CF bearings on eccentric cams that actuate rake teeth in their wool washers. The changeover reduced their original and replacement costs over 10% and reduced maintenance to occasional lubrication. Where previously, rollers only lasted a maximum of several months, no replacements have been required with the Multirol bearings. As a result, the Multirol Bearings solved a trouble spot that brought in many customer complaints.



Crown Rheostat and Supply Company of Chicago uses up to 200 Multirol Cam Followers as guide and support rollers in the travel and transfer mechanism of their cleaning, plating, and drying machines. Formerly trolleys were suspended from rails but the cam follower units proved to be a more precision means of friction reduction and added stability to the supporting arms.

Other McGILL® Bearings

MULTIROL CYR



MULTIROL SE

GUIDEROL CT

A new 140-page Bearing Reference Guide complete with 30 pages of vital engineering data has just been released by the McGill Manufacturing Company. It has the full story on the advantages of Multirol CF Bearings as well as information on the Multirol CYR, Multirol SE and Guiderol Bearings. Send now for your copy of McGill Catalog No. 52.

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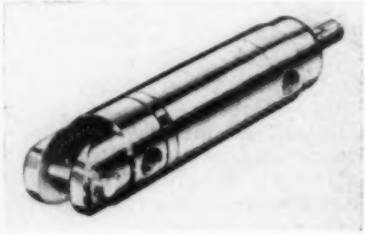
shoulder of the fastener provides a frictional "lock in" so that the fastener head stays in the wrench as a unit in any position to permit one-handed reaching into awkward spots, or for the inserting or removing of the fastener from any angle. In many cases, the "lock-in' feature eliminates hand-starting of the Fastener. Since the arc described by the socket or wrench is less when tightening or loosening a 12-point fastener, the turning of the fastener is easily accomplished in confined areas.

The Twelve-Point Fastener Co., 4517 Lorain Ave., Cleveland, Ohio

Air Cylinders Save Mounting Space

Eliminating tie rods and reducing head size, a saving of up to 40 percent in mounting space is possible in a new line of air cylinders. Added strength and high safety factor are obtained with solid steel heads and a heavy wall seamless steel body. Cylinder walls are honed and hard chrome plated, and have leakproof cylinder head to body construction.

Additional features are: Relative port positions may be rotated without



disassembly of cylinder and may be locked in any position; minimum center line to center-line mounting; heavy duty, hard chrome plated piston rod; self-adjusting piston rod packing; controlled packing compression; metallic rod wiper; piloted packing glands of added lengths.

The line is furnished in many standard sizes and styles, both cushioned, and non-cushioned.

The Tomkins-Johnson Co., Jackson, Mich.

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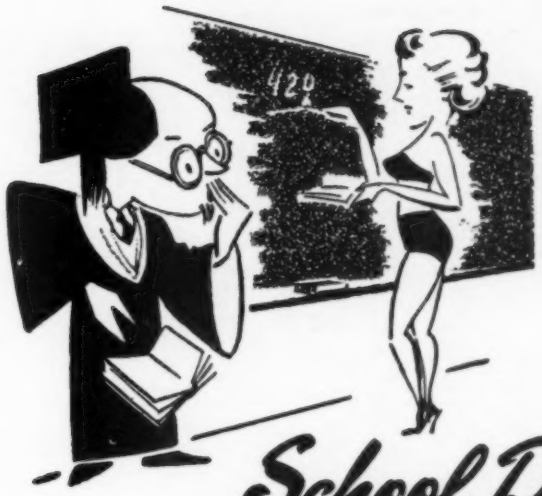
An alkaline electrolytic process for derusting of metals will accomplish effective and complete scale removal of metals by the use of periodic reverse current. Cathodic treatment of rusted steel and alloy steel parts accomplishes



School Daze!

Just because that bathing suit is proper at the beach, she shouldn't assume it's proper for the classroom, too!

And just because one bearing is best lubricated by one particular grade of oil, you shouldn't assume that the same oil is best for *all* bearings on that machine. In many cases it isn't.

OIL CUPS permit you to lubricate each bearing with the oil best suited to that bearing—thus prolonging bearing life, reducing maintenance costs, cutting down-time, boosting production. And oil cups fortunately *cost very little.*

Gits oil cups have been the standard for industry for more than 40 years. Gits Bros. has the largest selection of oil cups available anywhere. Call on Gits Bros. for a prompt, efficient solution to your lubrication problems.

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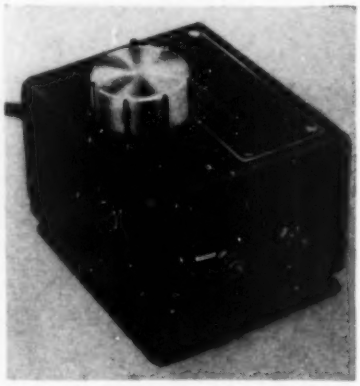
this rust removal without any attack upon the base metal. This makes the process applicable for removal of rust where no etching can be tolerated on the base metal, such as highly finished tools, rolls, ball bearings and high carbon steel parts.

The application of periodic reverse current, in which the work is made the anode from 5 to 30 seconds and then the cathode for a like period of time, gives clean removal of black heat treat, quenching, and other scales on steel and alloy steels. Bulk descaling of small parts has been accomplished in oblique tumbling barrels using a carbon electrode. Also, the periodic reverse alkaline descaling process is said to produce a better surface for hard chromium plating with less danger of hydrogen embrittlement than when acid descaling is done. The use of high current densities of 100 to 500 amp/ft.^{2} will remove scale from high carbon steel wire in from 1 to 2 minutes.

Enthone, Inc.,
442 Elm St., New Haven, Conn.

Portable Variable Transformer

For portable use in factory and laboratory, a new small variable transformer has a primary of 117 volts a-c, 50 watts, with the secondary from 7 to 13 volts a-c continuously variable and 4 amp continuous duty. It can be



used for 6 to 12 volt lamps, small motors, heater elements and for operation of a-c relays and solenoids.

The unit weighs three pounds, and measures 3½ in. x 4 in. x 3½ in. high. This transformer will take general use in either temporary or permanent factory installations, is valuable for experimental use in the laboratory, and will stand high overloads.

Pacific Transducer Corp.,
11921 West Pico Blvd.,
Los Angeles 64,Calif.

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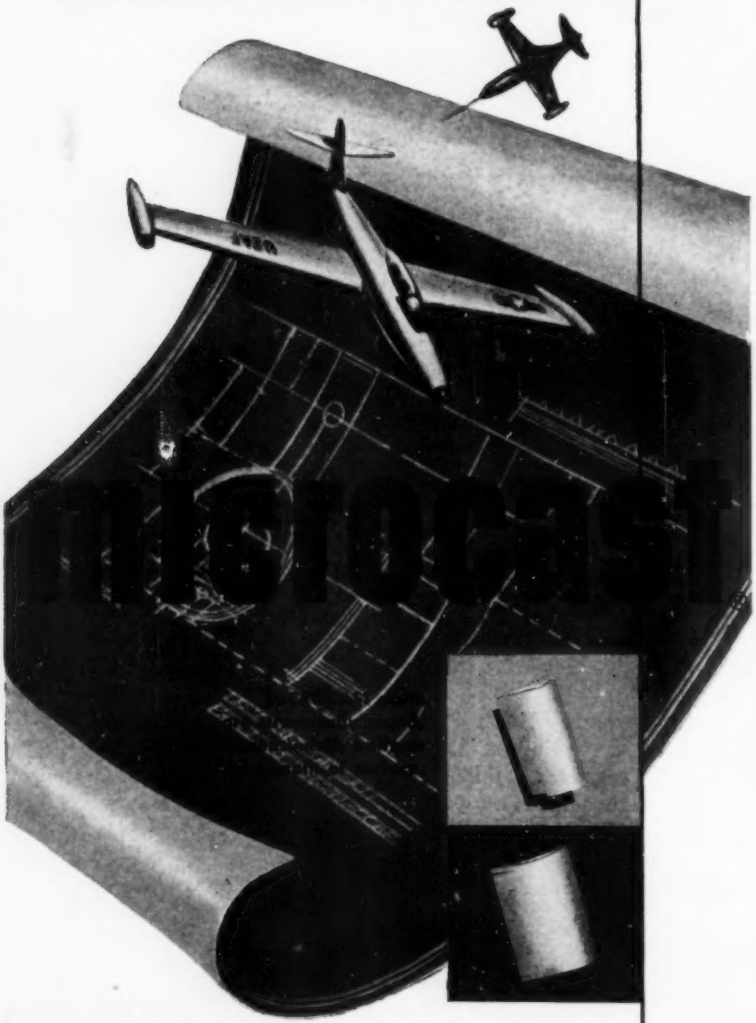

Complicated power blades and buckets for jet engines require the use of high-melting-point alloys that are slow and costly to produce by ordinary methods of manufacturing. The Microcast Process of investment casting produces these parts for use as cast, reducing machining and grinding operations to an absolute minimum. This process is particularly well suited to similar applications requiring the use of high-temperature alloys. Let us show you how MICROCAST parts can fit into your product's design.

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MEETINGS

March 9-12

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION—Annual Meeting, Edgewater Beach Hotel, Chicago, Ill.

March 15-19

AMERICAN CHEMICAL SOCIETY—National Meeting, Hotels Statler and Biltmore, Los Angeles, Calif.

March 16-20

NATIONAL ASSOCIATION OF CORROSION ENGINEERS—1953 Conference and Exhibition, Sherman Hotel, Chicago, Ill.

March 17-26

ROYAL NETHERLANDS INDUSTRIES FAIR—Utrecht, Holland.

March 18-20

AMERICAN SOCIETY OF TOOL ENGINEERS—Annual Meeting, Statler Hotel, Detroit, Mich.

March 23-26

INSTITUTE OF RADIO ENGINEERS—National Convention, Seminar, and Exhibition, Hotel Waldorf, Hotel Belmont Plaza, and Grand Central Palace, New York, N. Y.

March 23-27

AMERICAN SOCIETY FOR METALS—Western Metal Congress and Exposition, Pan-Pacific Auditorium, Los Angeles, Calif.

March 25-27

SOCIETY OF AUTOMOTIVE ENGINEERS—National Production Meeting, Hotel Statler, Cleveland, Ohio.

March 25-27

PRESSED METAL INSTITUTE—Annual Spring Technical Meeting, Hotel Carter, Cleveland, Ohio.

March 27

MALLEABLE FOUNDERS' SOCIETY—Western Sectional Meeting, Hotel Drake, Chicago, Ill.

March 21-April 2

MAGNESIUM ASSOCIATION—International Magnesium Exposition, Washington National Guard Armory, Washington, D. C.

April 18-19

PACKAGING MACHINERY MANUFACTURERS INSTITUTE—Semi-Annual Meeting, Sheraton Hotel, Chicago, Ill.

D.O.James

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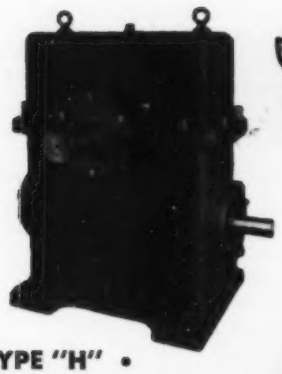

TYPE "H" •

Horizontal or Vertical Drive—Each drive type comes in 15 sizes, with ratio ranges of 5.6:1 to 100:1 and from .06 to 206 horsepower.

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Horizontal or Vertical Drive—Each type available in 8 sizes, ratio range of 5.66:1 to 100:1 and from .04 to 15.6 horsepower.

for the Best in

WORM GEARS AND WORM GEAR REDUCERS

MOTORIZED •

Horizontal or Vertical Drive—Each drive type comes in 11 sizes, has ratio range of 5.6:1 to 100:1, with ⅛ to 30 horsepower, driven speeds of 310 r.p.m. to 17.4 r.p.m. Vertical drive slow speed shaft extends either upward or downward.

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Horizontal or Vertical Drive—Each drive type available in 13 sizes, ratio range of 130:1 to 10000 and from .004 to 39.7 horsepower. Vertical drive slow speed shaft extends either upward or downward.

WORM GEARS

Generated on tangential feed hobbing machines by tapered and ground hobs. Made from 1" to 100" in diameter and from 24 DP to 1 DP.

Catalogs are available to users of Gears and Gear Reducers—containing valuable engineering data, specifications, weights and prices.

Send for Catalogs 45-B and 45-C for Complete Information on Worm Gear Reducers

D. O. JAMES Worm Gears and Worm Gear Reducers are designed and manufactured to have maximum inbuilt strength and to assure dependable *on-the-job* performance. The many and repeated installations of these reducers testify to their operating superiority and adaptability.

D. O. James GEAR MANUFACTURING COMPANY

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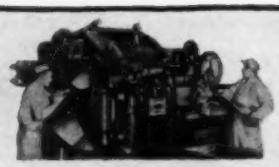
SINCE 1888—MAKERS OF ALL TYPES OF GEARS AND GEAR SPEED REDUCERS



"THIS LUBRICANT INCREASED BEARING LIFE FROM 2 WEEKS TO 2 YEARS"

—says THE GLOBE COMPANY

"Animal acids and moisture, most harmful to ball and roller bearings prevails in the entire meat packing industry. With conventional lubricants, some of the bearings in our Roto-Cut machines did not last two weeks. Since using Ball Bearing LUBRIPLATE in machines operating continuously 24 hours a day for over two years, we have not had a single bearing replacement."

For nearest LUBRIPLATE distributor, see Classified Telephone Directory. Send for free 56-page "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

Sans, Souci

Ad Libbing by the Editor

The other day I got a letter from Alfred J. Koorey, Research Associate in the School of Engineering at The Pennsylvania State College. He stated, "I would like to add my humble thoughts to the passing parade by suggesting that, 'Necessity may be the Mother of Invention . . . but Competition is the Father of Research.'" It is true that many inventions are born out of sheer necessity and unquestionably many companies are compelled to undertake research for no other reason than that their competition compels them to.

In thinking back over the years, I am forced to the conclusion that a company that does not undertake research until it is forced to do so by competition will usually find itself bankrupt or pretty close to it before there are any fruits of research.

Research, be it pure science research or applied research is not a matter of laboratories and organization charts and bellicose reports. It is a state of mind. It is a way of thinking, plus the necessary tools for thinking. Leonardo da Vinci did not have a wonderful laboratory with electronic calculators, testing machines of all kinds, staff assistants and technicians. All he had was a wonderful mind and a way of using it. The important point is that da Vinci possessed the essential ingredient for successful research. Admittedly, now that we are digging deep into the bowels of knowledge it is necessary, in addition to the research workers, to provide laboratories, excellent working conditions, an atmosphere conducive to calm thinking plus all of the contrivances that might facilitate and stimulate the birth of original ideas.

In some companies the beginning of a research department follows along the same general lines. Some among the top brass get the idea they must do research. The first step is then to appoint from within the organization or hire from outside the organization a research director. Step number two is to give to the research director suitable working space. This working space will vary all the way from a single one room office to a huge edifice that bespeaks wealth and grandeur. Step number three is for various individuals among the top brass to suggest research projects. These might range

Heavy-duty Model 1065 shown. ⅓ to 2 HP, 3.8 to 21 CFM, 10 to 30 PSI. Direct or V-belt.

Light-duty Model 0440 shown. ¼ to ⅓ HP, 2 to 5.6 CFM, 7 to 20 PSI. Direct or V-belt.

Integral Motor—Pump Model 0210, ¼ HP, 1.3 CFM, to 25 PSI.

V-belt Dual Chamber 10 x 1040. 9 CFM each side, vac. to 20", pres. to 20 lbs.

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Offer your customers better performance, better appearance! Specify Gast rotary-vane Air Compressors as original equipment on products where compressed air of 10 to 30 lbs. is needed. Select from 1.3 to 24 CFM range—numerous sizes and combinations. Precision built; integral-motor, V-belt or direct drive models; standard accessories.

Investigate! See why Gast Air Compressors give you specific advantages for aerating, atomizing, blowing, liquid displacing, etc.

Write for Catalog and Application Ideas Booklet!

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AIR MOTORS · COMPRESSORS · VACUUM PUMPS

(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)

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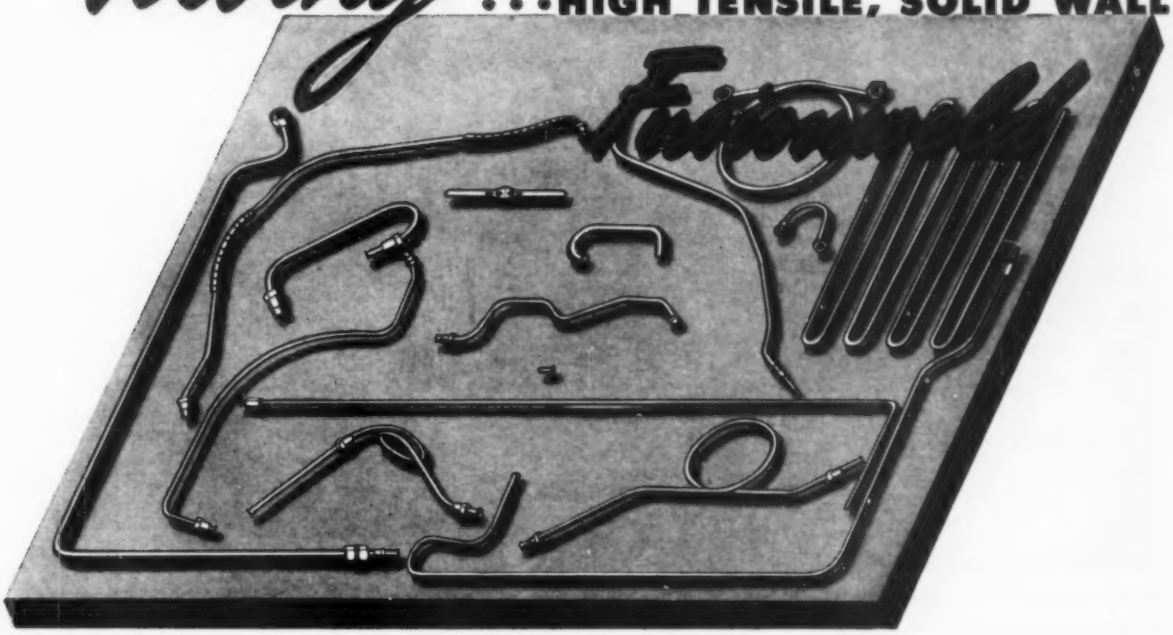

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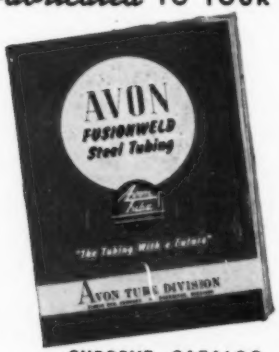
Fabricated **TO YOUR PRINT**



CURRENT CATALOG ON REQUEST

● Avon Fusionweld—thin wall steel tubing—serves a constantly expanding variety of industrial needs . . . is fusion welded under a new, rigidly controlled hi-cycle process to insure uniformity of wall strength and structure . . . meets the highest standards for tensile strength, ductility, resistance to fatigue and pressures.

Available in straight lengths or continuous coils. May be specified "as welded" for miscellaneous commercial purposes; "hard drawn" in machining operations where threading, knurling, piercing, are specified; "annealed" to serve the most difficult problems of bending, flaring, swaging, beading and coiling without cracking, tearing or checking—to carry fluids under high pressures.

Widely used in automotive, refrigeration, air conditioning, space heater, stove, electrical, radio, TV and toy manufacturing industries. Post yourself on the superior economy and performance of Fusionweld—truly the tubing with a future! Let Avon help you find a more suitable answer to your tubing problems.

FUSIONWELD...THE TUBING WITH A FUTURE

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Geared to Industry's Production Demands Since 1887 . . .

Over a period of 65 years, producing standard and special washers of all types for all industries, we have made up more than 25,000 sets of dies . . . used in the production of washers which are stocked in thousands of different sizes. On special orders we will make up dies to your specifications.

Let us quote on your requirements for washers and stampings . . . covering fabrication in any material and any finish . . . machined, heat-treated or surface ground, as may be specified.

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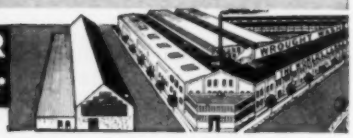

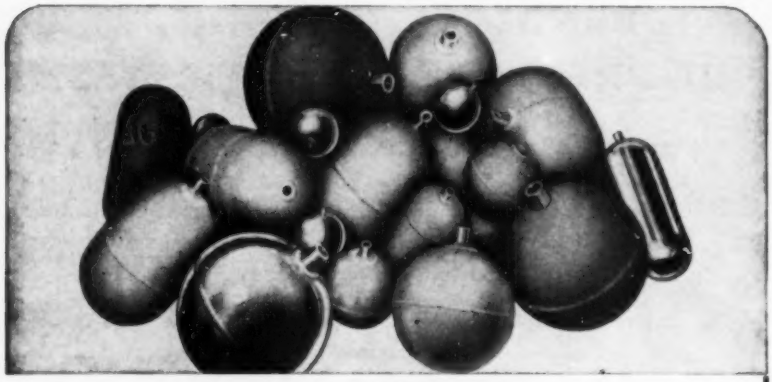

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FLOAT BULLETIN 650

Complete Data on Welded Floats; Diagrams, Tables, Formulae for Calculating Buoyancies

The booklet is a standard reference for specifiers of welded floats. Nicholson furnishes any type for external or internal pressures; in stainless steel, Monel, chromium, cadmium or copper - plated steel. Sizes, 2" to 14" diam., press. to 4800 lbs.; standard or special connections. Quick delivery on many sizes and shapes. Nicholson floats are standard with hundreds of manufacturers.

W. H. NICHOLSON & CO.

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200 OREGON ST. WILKES-BARRE, PA.

all the way from the development of the design of a gearless differential to the formulation of a material that will have the strength of steel, the elasticity and softness of rubber and that will be a perfect heat conductor but also a perfect electrical insulator. Then there follow some pet projects stimulated by the needs and desires of company officers. The next step is either the beginning of true research or the swift demise of a bad beginning.

A Terrible Disease

About two years ago Walter H. Kohl of Collins Radio Company, Cedar Rapids, Iowa, had an interesting little article in the proceedings of the Institute of Radio Engineers. Among other things he said, "Although information and general directives are most conveniently distributed by memoranda, an organization should be on its guard against the not altogether rare disease which might be called 'memoranditis'. It thrives in all climates, desregards age or sex, feeds on reams of paper, and incidentally destroys the morale of the people affected by it. It makes its appearance singly or in multiple copies. The vicious kind feeds on arguments. To send such missiles to the fellow next door, so to speak, is very poor technique. It is much better to talk things out than to write them out."

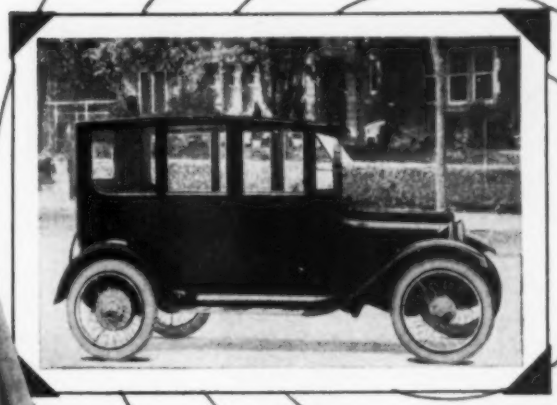
Most readers will agree with Mr. Kohl. In fact, they might even send him a memorandum about it. But, seriously, the extravagant use of memoranda is one of the curses of business. The companion curse is the filing of memoranda plus everything else.

It seems to be a weakness of human nature to save anything and everything, and especially correspondence. There is an old proverb, "Merely that I have it, saith the raven." The explanation is that the raven is a natural thief who steals everything and anything and stores it away. The stuff is entirely useless to the bird but being that kind of a bird the raven goes to great pains to gather the junk and hide it away some place.

That is exactly what humans love to do with correspondence. They want a file on this and a file on that. For years and years correspondence and memoranda are filed away with greatest care. But nobody ever looks at it.

Recently there was an article broadcast by the Associated Press written by Sam Dawson. According to that article the results of a survey show that 95 percent of the papers filed by the nation's firms are never used again. One might suspect that most of the five

another case where welded steel tubing does the job best . . .



HOW we took the rumble out of grandpa's sedan . . .

● Remember the rumble and roar that began when the old-style drive shaft under the floor started vibrating and whipping at 40 MPH.?

Today's automobiles can travel at twice Grandpa's speed with never a whisper of whip and rumble from the propeller shaft. Many such shafts are Republic ELECTRUNITE Tubing...uniformly round, fully concentric, with uniform wall thickness all around the tube and from end-to-end. There can be no heavy spots or light spots to throw the rotating tube out of balance.

Another advantage . . . Republic ELECTRUNITE Tubing has plenty of strength to withstand the reversal of torque when you release the accelerator and change from engine-driving to engine-braking conditions. The uniform walls of the light-and-strong hollow steel tube can "take" this twist for hundreds of thousands of miles.

This propeller shaft should give you the idea that welded steel tubing made the Republic ELECTRUNITE Way can take a lot of punishment . . . and come back for more. We'd like to tell you *all* the things that Republic ELECTRUNITE Tubing is doing successfully, and at lower cost. Write to:

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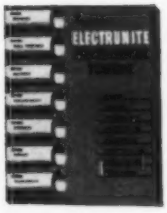
REPUBLIC STEEL CORPORATION
222 East 131st Street • Cleveland 8, Ohio



Write for this booklet of design data and ideas on Republic ELECTRUNITE *Mechanical Tubing. Ask for "Booklet STMT 100."*

REPUBLIC STEEL

ELECTRUNITE TUBING

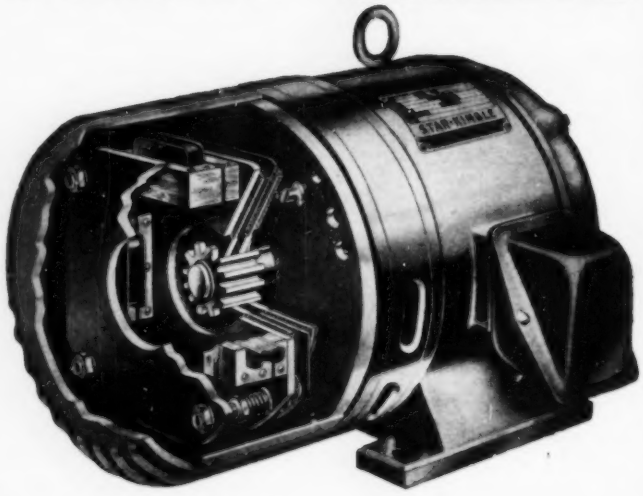
STOP! START STOP! START STOP! START STOP!

START STOP! START STOP! START STOP! START

START STOP! START STOP! START STOP! START

Instantaneous Drag-free

STOPS! STARTS



STOP! START STOP! START STOP! START STOP!

minute after minute YEAR AFTER YEAR with Star-Kimble Brakemotors

That extra-large brakelining area you see brings a Star-Kimble Brakemotor and its connected load to an *extra-fast stop*—as short as a fifth of a second from full speed to standstill if desired.

And the small air gap contributes to *equally fast starts*. Brake is released the instant motor current is switched on—equipment starts without drag.

That's the story of a *single* Star-Kimble stop-start cycle. And the experience of user after user *proves* that Star-Kimble Brakemotors *maintain* the same split-second stops, the same smooth starts, through hundreds of thousands of cycles. In reversing service, conventional plugging methods with a typical 5 hp motor allow only 3 starts per minute. With a Star-Kimble Brakemotor, the figure is boosted to 10!

Of course, every Star-Kimble Brakemotor is a compact, integral unit designed to save space—and give rugged, dependable performance. One manufacturer—one responsibility.

For the full story, write for Bulletin B-501-A

STAR-KIMBLE

MOTOR DIVISION

...EHLE PRINTING PRESS AND MFG. CO.

211 Bloomfield Avenue Bloomfield, New Jersey

percent of the papers that are referred to again are of little real value.

In reporting this study which was released by the National Records Management Council, corporate records now occupy office space valued at one hundred and fifty million dollars per year plus outside office storage space valued at between one hundred and fifty to two hundred and fifty million dollars per year. That totals about one-third of a billion dollars. It is estimated that one trillion pieces of paper are stuffed in the nation's business files. Much of this material could be burned or sold as waste paper without anybody missing it. The government's hoard of papers fills eighteen and one-half million cubic feet of filing space in spite of the fact that the federal agencies have been destroying two and one-half million cubic feet of records annually, effecting a saving of nearly five and one-half million dollars per year.

According to the report, Emmet J. Leahy, president of the National Records Management Council, believes that business firms are worse offenders than the government in the matter of record keeping.

Right along the same line of record keeping is the matter of sending copies of correspondence to various individuals. Here is a place where the engineering department is a great offender. It is a simple matter to find out who really needs copies of the prints. The way it is done is simply to stop sending a copy of the new prints to Mr. Jones who thinks he needs a copy of every print. If he fails to squawk for his copies we have established the fact that he really does not need them. Following this procedure in batches of ten percent of the recipients of copies every month, it becomes a very simple procedure to reduce the copies of prints, change notices and similar memoranda to a minimum. One company that followed this procedure achieved a saving of thirty thousand dollars per year in the cost of blueprints and extra copies of notices. To this saving must be added the savings in messenger girl service, the savings in the handling time involved and all the other intangibles.

Of course it is always possible to make a mistake in a matter of this kind which brings up another subject. At one of the crucial football games of a great university the right tackle failed to take out his man on one of the important plays. The coach immediately yanked him out of the game and as the young fellow came off the field he meekly looked at the coach and said, "I am sorry, coach." To this

Why worry NOW about product costs?

Company sales are good!
And everybody's prices are high!

HOLD ON A MINUTE, THOUGH!

Detroit's cut price tags on '53 cars—and put a sales push behind them. Looks as if competition is here again. So why don't **you** keep a step ahead of **your** front office?

Be the **first** in your company to plug new product thinking—cost-wise and performance-wise.

Here's an idea: specify

"COMPO"® and "POWDIRON"® bearings and parts

("COMPO" (porous bronze) "POWDIRON" (sintered iron))

These oil-retaining products of Bound Brook powder metallurgy . . .

last for years without attention. Often **outlast** the product in which they are installed.

Cut down on size of metal housings.

Need no skilled labor to install.

Like to know what to *tell* front office about these bearings and parts? Our bulletins on advantages, applications, installation methods will give you all the ammunition you need. Just write for copies.

Buy Bound Brook

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Bound Brook, N. J. **Bound Brook 9-0441**
MANUFACTURERS OF BEARINGS AND PARTS • ESTABLISHED 1883

AHEAD OF THE VAPOR TRAIL . . .

LEBANON Castings ARE AT WORK

THAT streak in the sky is a Curtiss-Wright Sapphire J-65 Turbo Jet Engine powering a high-altitude plane. The intense heat—approximately 1500° F.—developed during flight is enough to disintegrate "normal" materials, formed in the usual way. Yet in this inferno of power Lebanon Stainless Steel Centrifugal* Castings of special heat-resistant alloys are giving dependable service as . . .

TURBINE SHROUDS
HEAT SHIELD SUPPORTS
EXHAUST CONE FLANGES
COMBUSTION CHAMBER FLANGES
TURBINE BLADE SPACER RINGS

*"CENTRI-DIE", patented name for method of casting steel centrifugally in metal molds, under license agreement with Firth-Vickers Stainless Steels Limited, Sheffield, England. Lebanon also makes steel castings, both static and centrifugal, in refractory molds.

Have you seen . . .
STEEL WITH A THOUSAND QUALITIES?
This 37-min., 16 mm., full-color sound film showing steel castings from blueprint to end use should be shown to your organization. For information, write: Dept. C, Lebanon Steel Foundry, Lebanon, Pa.

LEBANON Castings
CARBON, SPECIAL ALLOY AND STAINLESS STEEL

the coach replied, "Don't be sorry, be right!" Those five words, spoken without sarcasm and with great force and sincerity made a tremendous impression upon the young football player. He has never forgotten the expression. Today he is president of his company and I am quite sure that the pointed advice given to him by his coach has played a great part in that man's success.

It is all right to regret an act, but it is far better to determine that it shall not occur again, and other than that forget it. Self recrimination leads to self pity which finally ends in weakening character. Strong men do not dwell upon their mistakes. They correct them and then forge ahead, forgetting the mistake but remembering never to let it occur again.

—G.F.N.

Automatic Recognizer May Replace Telephone Dial

SCIENTISTS AT THE BELL TELEPHONE LABORATORIES have developed an experimental electronic device that can recognize numbers spoken into it. Named "Audrey", for automatic digit recognizer, the unit automatically determines which of ten numbers from "1" through "0" has been spoken into an ordinary telephone.

Basically, Audrey is a combination of the relays already used in modern dial telephone systems. It operates on a principle of memory and matching.

Numbers, spoken into it, are stored in a memory cell; the device then sorts the speech sounds into electrical categories which conform in their own medium to sound wave patterns. By matching these categories against standard reference patterns set up electronically, the machine can pick out the standard pattern that best fits the electrical pattern. This actuates a set of relays to close a particular circuit.

Bell Labs warns that the device is not yet perfected. Dialing will stay with telephones for some years to come since several problems are yet to be solved. Typical examples: Audrey will not respond to a variety of speakers unless it is first adjusted for each voice; it will not tolerate careless enunciations or accents; and it cannot understand words as yet.

But telephone people have great hopes for the device. Eventually, they visualize completing calls by simply speaking the desired number into the mouthpiece of the telephone.

MAXITORQ *automatic*

OVERLOAD RELEASE

CLUTCH

To designers and manufacturers of high-speed automatic machinery, Carlyle Johnson offers practical engineering recommendations for applications of this protective power transmission unit.

Let's consider, for instance, a can or bottle labeling machine . . . when an accidental overload shock occurs. Labels go flying all over the place, cans or bottles gang up and are dented or broken, the driving mechanism is jammed . . . and all that costs money and down-time.

But not if your original power transmission is controlled by the Maxitorq automatic Overload Release Clutch, which is manually adjusted to transmit the normal running load and instantly disengages into neutral when the overload strikes. With a minimum of clean-up, the clutch is re-engaged . . . and all is well.

Overload Release Cups (note the cam construction) are the means by which the clutch is connected to the driven or driving member. We make them at relatively low cost . . . and can also supply hub, ring, flange, or cut-off coupling types to suit your specific conditions. Clutches standardized in 6 sizes, ¼ to 5 H.P. @ 100 r.p.m.; working torque, 13 to 263 ft. lbs.

Send for bulletin PE-150-3

THE CARLYLE JOHNSON MACHINE CO.

MANCHESTER . . . . . CONNECTICUT

SCJ53

Frankly SPEAKING

There are quite a few types of clutches but, within its capacity, the Maxitorq Floating Disc Clutch is not excelled in applications for which it is intended. The Carlyle Johnson Machine Company is celebrating its 50th anniversary of clutch manufacture. Throughout those years, our engineers have developed new design features, more and more compact construction, improved wearing qualities, and better machining practices for maintaining reasonable costs.

Perhaps the outstanding design feature is the patented "Separator Springs," a definite improvement that moved multiple disc clutches up to the front line. Used between each pair of inner discs, they spread them endways with an accordion action, so that light may be seen between all discs when the clutch is in neutral. Therefore, there is no drag, no abrasion, no heating. The discs actually "float" or ride free when the clutch is in the neutral position.

Carlyle Johnson's method of finishing the engaging faces of the discs assures flat, true surfaces. This means that under engagement there are no high or low spots . . . the entire area of the surfaces has an evenly distributed contact. Obviously, disc service life is greatly extended. Such refinements are the result of continuous study by our engineers to make and keep the Maxitorq name high on the list of machine and product designers for their original equipment for control of power transmission.

Your problems are in good hands if you put them up to our engineers for solution. We've traveled the country over to check on the best and most practical installations . . . and we're on call whenever a problem arises. Just ask for Frank R. Simon, The Carlyle Johnson Machine Company, Manchester, Conn.

when quality counts and accuracy is important

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Standard Stamping

for all perforated metals, plastics, masonites, papers

STANDARD will perforate your material—or from our stock on hand to your specifications.

STANDARD has complete fabricating facilities: bending, drawing, punching, welding.

STANDARD has a complete selection of dies and a staff to create custom dies in record time at the best price!

Standard STAMPING & PERFORATING COMPANY
3131 West 49th Place, Chicago 32, Ill.

Write now for more information and for a copy of our new folder "There Are Holes in Our Story."
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Company
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City Zone State

American Sports Car Nears Production

AN AMERICAN SPORTS CAR having a laminated fiber glass body will be placed in production in July by Kaiser-Frazer Corp. Initial schedule calls for 2,000 units.

Designated as DKF-161, the new sports model will incorporate many new and distinctive features. It is claimed that American interest in an American-built European type sports car speeded up K-F's decision to volume produce the new units.

Plastic Cuts Lead-Wire Deterioration

PLASTIC IMPREGNATED LEAD-WIRES are being installed on aircraft engines to replace rubber covered type which deteriorated from ozone and high temperature deterioration, according to B. F. Goodrich Co.

Carrying high voltage from the transformer coil to a spark plug, the leadwire consists of multiple layers of nickel braid with Geon vinyl paste resin sandwiched between each layer.

Use of the plastic impregnation braid combination, reduces total weight of the lead-wire and makes it more flexible than the older flexible metal tube insert assembly. Other advantages claimed are the plastic's resistance to effects of engine flushing solvents and not to support combustion.

New X-ray Sharpens Medical Research

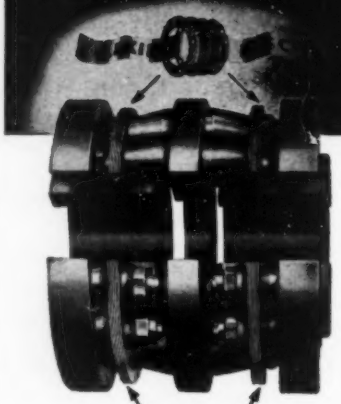
THREE-DIMENSIONAL X-RAY MOTION PICTURES promise to aid the study and diagnosis of congenital heart disease, as well as joint and chest diseases, by showing clearly the relative positions of organs both in normal and abnormal conditions.

Novel feature of the development by Rochester University's Medical School is that the method requires no modification of existing cinefluorographic camera. Film produced can be used for conventional motion picture projection as well as stereoscopic.

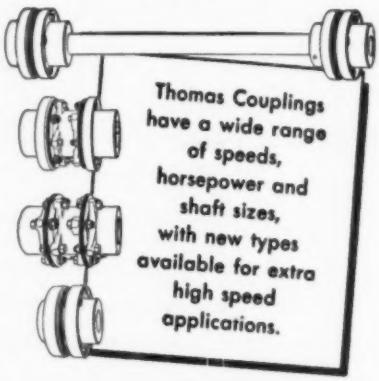
One camera, either a 35 mm or 70 mm, is used to photograph the subject. Stereoscopic effect is obtained by a moving X-ray tube synchronized to move in an arc maintaining the position of the X-ray beam on the subject. The moving X-ray tube, and the synchronized rotation of the subject on a revolving chair operated by an electric mechanism, give the necessary image shift to create the binocular effect necessary for stereoscopic visualization of the image. Two prints of the film are made.

AVOID COSTLY SHUT-DOWNS!
. . . your machines will last longer with Thomas Couplings

Distinctive Advantages of THOMAS FLEXIBLE COUPLINGS
- NO MAINTENANCE
- NO LUBRICATION
- NO BACKLASH
- NO WEARING PARTS



Patented Flexible Disc Rings of special steel transmit the power and provide for parallel and angular misalignment as well as free end float.



Thomas Couplings have a wide range of speeds, horsepower and shaft sizes, with new types available for extra high speed applications.

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ENGINEERING ABSTRACTS

Increasing System Reliability With Magnetic Amplifiers

Abstracted from "What Magnetic Amplifiers Can Do To Increase Aircraft Reliability" by George F. Schroeder, Asst. Chief Engineer, Ford Instrument Co. as presented before The Institute of the Aeronautical Sciences, January 28, 1953.

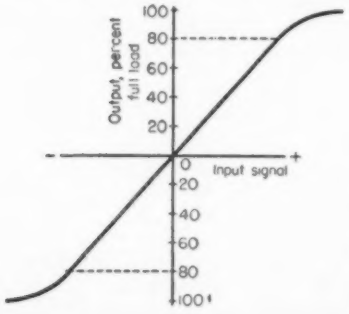
THE SATURABLE REACTOR or magnetic amplifying element can function in one of several capacities: As an amplifier, relay device, voltage or frequency sensing element. Consequently, the reactors are applicable to many diverse types of airborne equipments such as: navigational computing instruments; armament control systems; rocket control devices; power-driven gun turrets; radar antenna drives; control surface and landing-gear systems; frequency changers and converters; autopilots; boosters; and radar.

For application purposes, magnetic amplifiers are evaluated on the basis of the following criteria: sensitivity, gain, linearity, response time, and stability.

Amplifiers sensitive to signals less than one milliwatt include magnetic amplification of such low energy signals as those derived from thermocouples, control transformers, potentiometers and various sensing devices.

Power gains of single stage amplifiers have reached one million. Although there is no theoretical limit to single-stage power gains, practical considerations usually limit amplification to much lower values. The controlling factors in addition to those of fabrication, are linearity, circuit stability and signal-to-noise ratio.

Thus, where relatively large gains are required, it is necessary to cascade two or more stages. The input stage is operated at low power and voltage levels, thereby increasing sensitivity over that of an equivalent single-stage



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This molding is another illustration of the use of rubber to replace corrosive metals. Formulated and produced by Roth in cooperation with the Jefferson Electric Company to meet military and CAA performance requirements under all operational conditions in any climate, it shows how Roth chemists and engineers apply their knowledge of the latest developments in rubber technology to the solution of the customer's design, performance and cost problems.

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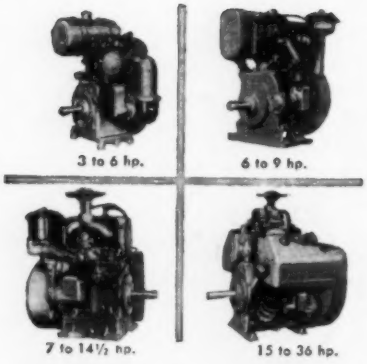

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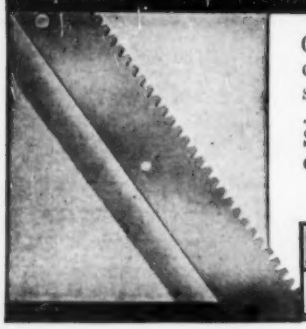

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amplifier. By working with lower voltages, smaller rectifiers can be used in each stage. In addition, voltages induced in the control windings are minimized, facilitating their reduction to a negligible level at the input signal source by the balancing effect of the amplifier circuits.

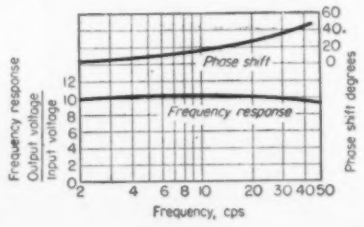
Linearity of a typical half-wave bridge stage is shown by the gain curve, Fig. 1. There is a constant output-input ratio up to 80 percent of the output load, and above 80 percent the curve becomes non-linear. Depending upon the requirements of the particular circuit, linearity can be extended over a larger range of input signals by the use of negative feedback at the cost of some gain.

The amplifier time constant should be as small as possible and symmetrical, that is, the same for both increasing and decreasing signals. By suitable design techniques, magnetic amplifiers can be made to satisfy the response time requirements for most applications.

Response time for a single-stage self-saturating circuit has a theoretical minimum of one-half cycle since the rectifier in series with the anode winding de-energizes the reactor for one-half cycle. For example, a 400 cycle system responds in less than one-sixth the time of a 60 cycle system. At higher frequencies, the effect of the shunt capacitance of the common types of rectifier cells becomes appreciable which gives rise to circuit instability. If germanium crystal or similar rectifiers are used, it is possible to reach the megacycle range.

To develop circuits that have response times approaching the theoretical minimum of one-half cycle, it is necessary to minimize the magnitude of the circulating currents. With large circulating currents present, the system takes longer to reach its steady state. Also, the system suffers losses in gain and sensitivity. Special circuits have been devised to minimize this effect.

A more thorough representation amplifier performance than response time is given by the frequency response characteristics of Fig. 2, which is a plot of such data for a single-stage circuit having a modulated 400 cycle input signal. The abscissa scale represents



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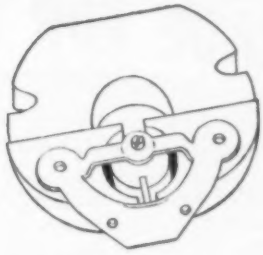

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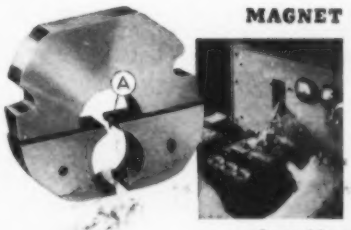
Of the various elements that make up an electrical instrument, perhaps the most important is its magnetic system. The ***strength, uniformity*** and ***stability*** of the magnetic field determine the degree of accuracy and reliability of the instrument. Here is how Marion design provides a magnetic structure of great strength, uniformity and stability, and at the same time keeps weight and cost at a minimum:

MAGNET

All Marion magnets are large, well-aged, precisely ground Alnico II or Alnico V, carefully checked for magnetic uniformity and maximum stable energy.

POLE PIECES

All Marion instruments use sintered and annealed high-permeability, *full* soft-iron pole pieces, of the type employed in the *finest* of laboratory instruments.



MAGNET ASSEMBLY

The pole pieces are permanently fastened to the magnet by induction soldering. Spring loaded fixtures force excess solder out of the seams, leaving a thin film of great bond strength and low magnetic loss. Final separation (A) of pole pieces is done *after* soldering operation, holding gap concentricity to better than .001".

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All Marion "Regulars" use closely machined soft-iron cores which are precisely oriented in the air gap by the instrument frame. (They are not jig located).

These magnetic systems represent a simple, honest means of providing uniform stable magnetic fields for Marion Indicating Instruments. They *never* include laminations, intricate magnetic stampings or uncertain mechanical assembly of the components of the magnetic system.

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The design of these instruments has stayed abreast of new materials and the latest in manufacturing methods. At the same time they have retained the basic simplicity of Marion functional design. This, combined with an efficient, cost-conscious manufacturing organization, affords finer instruments at lower cost.

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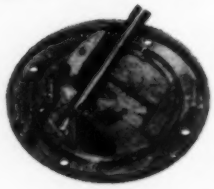
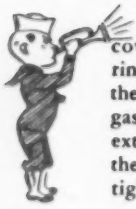
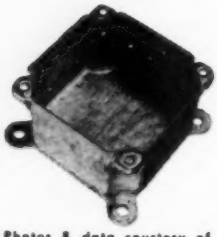




ASSEMBLY – Posts are placed in cover (above) with EASY-FLO wire rings around them. The heavier rings on the 3 posts touching the gasket, braze gasket and posts. Capillarity draws the extremely free-flowing EASY-FLO all the way around, making a strong, leak-tight joint.



Photos & data courtesy of Edwards & Co., Norwalk, Conn.

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modulation frequencies; the left ordinate scale gives the ratio of output to input voltages, and the right ordinate scale shows phase shift.

Amplifier output is essentially flat to 40 cycles or 250 radians, so that throughout this range, the phase lag is less than 40 degrees. These characteristics lend themselves to servo applications. It can be seen that phase lag is the resultant of a fixed time delay and the normal minimum phase characteristic.

Circuit stability can be judged by the effects of variations in frequency, line voltage, temperature and age. In most of the older magnetic amplifier circuits, variations in supply voltage had a marked effect on output. By using bridge-type circuits, it is possible to reduce appreciably the effects of line voltage and frequency variations. Effect of temperature on rectifier leakage and rectifier aging are reduced by shunting the rectifier with a resistor having a lower resistance than the back resistance of the rectifier itself. In this way, the two resistances in parallel are practically constant.

Designing for Rubber Phenolics

Abstracted from "Engineering Design for Rubber-Phenolics," presented by A. P. Landall, General Electric Co., before Janauary 1952 meeting of the Society of Plastics Engineers.

DURING THE LAST FIVE YEARS since the initial introduction of the rubber phenolic materials, there has been a steady growth of these materials for special jobs which could not be satisfactorily accomplished by the more conventional phenolics. The activity in this field has necessitated the development of new design concepts. For example, the fatigue impact of the rubber-phenolic appears to be 5 times that of its conventional counterpart. This relationship has been borne out by many practical applications.

Perhaps the first design consideration is one of shrinkage. The general purpose phenolics are generally considered to have a mold shrinkage of 0.007 to 0.008 in. per inch. The rubber-phenolics should be designed for 0.009 to 0.010 in. per inch. This indifference of 0.002 in. is exhibited across the board on all the rubber-phenolic family. It is a result of experience which has been gained in the field over the last few years. It does not mean that the rubber-phenolics cannot be used in molds previously designed for other materials; but rather that the tolerances would be broader. Molds already in use on other materials

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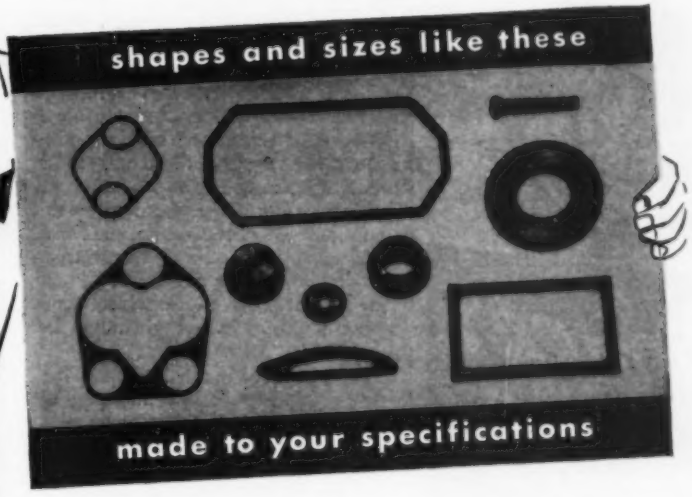

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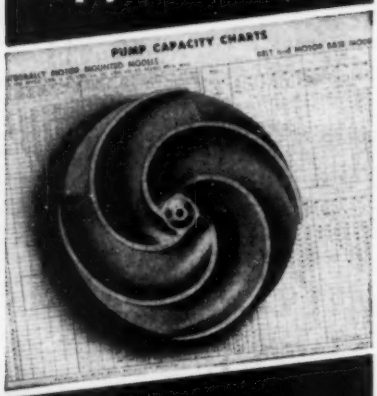

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Engineering Abstracts.....continued

have been successfully used on rubber-phenolics, but have been, by and large, jobs where dimensional tolerances were not too critical.

This brings up the question of dimensional tolerance. Generally speaking, the tolerances that can be expected with the rubber-phenolics are plus or minus 0.001 in. greater than the conventional woodflour filled phenolics.

In the design of molds for rubber-phenolics, an allowance of ½ deg per side should be used for draft. Naturally, undercuts and deadend pockets should be avoided wherever possible, and this is particularly necessary for the successful molding of the rubber-phenolic materials, due to the vulcanizing system used which is necessary to cure the rubber portion. The rubber-phenolic materials are somewhat more gassey than their conventional counterparts and need, therefore, some means of getting rid of the excessive gas formed during the molding operation. It is generally recommended that bleeders at the parting line or flash vents be provided, along the knock-out pins, particularly those which tend to be in sections where gas might be trapped.

The surface of the mold is quite important in the successful molding of rubber-phenolics. It is recommended that a good high polish mold be used, and it is certainly advisable to chrome plate. If molded-in holes are to be considered, it is recommended that the pins making these holes be polished by draw polishing. Avoid scratches or marks at right angles to the axis of the pin. This is necessary to avoid any possibility of binding during the ejection of the part from the mold. Warpage particularly plagues those who would successfully mold rubber-phenolic materials. To minimize the effects:

Check pressure—reduce if possible. Check gates—relocate if indicated. Check closing speed—slow down. Check ejection. Relocate or enlarge knockouts if indicated. Look for possible binding or cooking action. Check cure—increase cure if necessary. Check cooling fixture—provide if necessary. Remember that the rubber-phenolics are a rubbery material, particularly on discharge and, therefore, handling must be done with care. More warpage is occasioned by careless handling than by any other single reason. Very frequently, all that is required to keep warpage at a minimum is the placing of a proper sized weight on top of the molded part until it is sufficiently cooled to be satisfactorily handled. The rubber-phenolics have a very long duration of flow and are capable of exceedingly long drawn applications.

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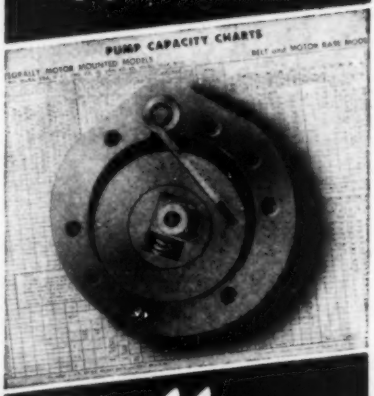

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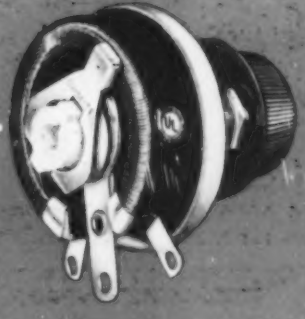

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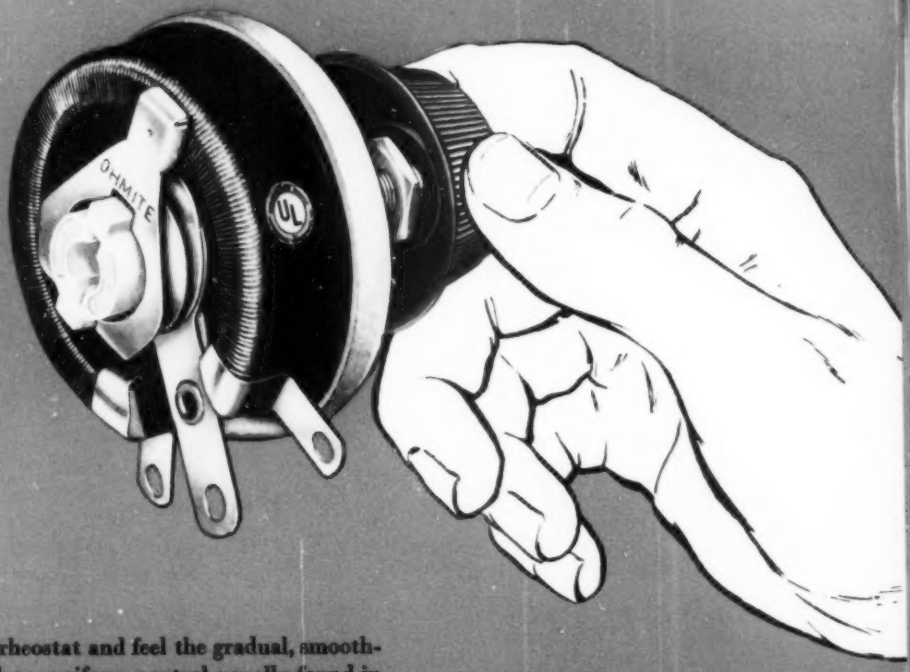

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The use of reinforcing ribs are not as necessary as in the woodflour-filled standard phenolic materials, however, should they be desirable, there is no problem in the design or molding of these ribs and bosses. Rubber-phenolic materials can be molded in any conventional type mold. In compression molding, it is advisable to stick to the positive or semi-positive type molds in order to obtain as much back pressure as possible. The design of transfer molds should follow conventional lines; however, the runner and gate design should be carefully located to insure even filling of the cavity.

High Pressure Cylinders

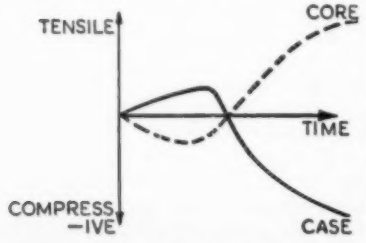
Abstract of "A New Approach to the Design of High Pressure Cylinders". *Mechanimal World and Engineering Record*, London, December 1952.

DATA FROM RECENT INVESTIGATIONS that provide information on the characteristics of thick cylinders and a method of approach for predicting their behavior under internal pressure with reasonable accuracy. The discussion is principally concerned with the determination of the internal pressure at which material in some part of the cylinder wall reaches the elastitc limit.

A cylinder made from heat-treated steel may have a stress distribution that varies during quenching as indicated in the accompanying figure. As cooling progresses the stress in the material changes in sign; the final result is that the stress is tensile at the bore and compressive at the case. Since such residual stresses, if present, may either supplement or reduce the stress imposed by the internal pressure, a method of evaluating the residual stresses is of interest.

To determine the residual stresses for a particular design of cylinder, it is necessary to destroy a sample cylinder, but the information gained can be used in evaluating the strength of other cylinders of similar physical dimensions, material and heat-treatment.

The method adopted is that suggested by G. Sachs (See "Residual



VARIATIONS OF STRESS in a heat-treated steel cylinder during quenching.

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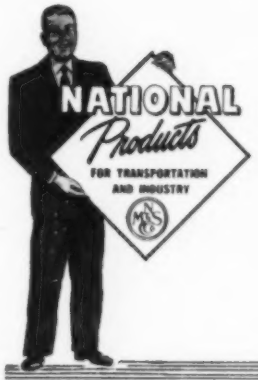

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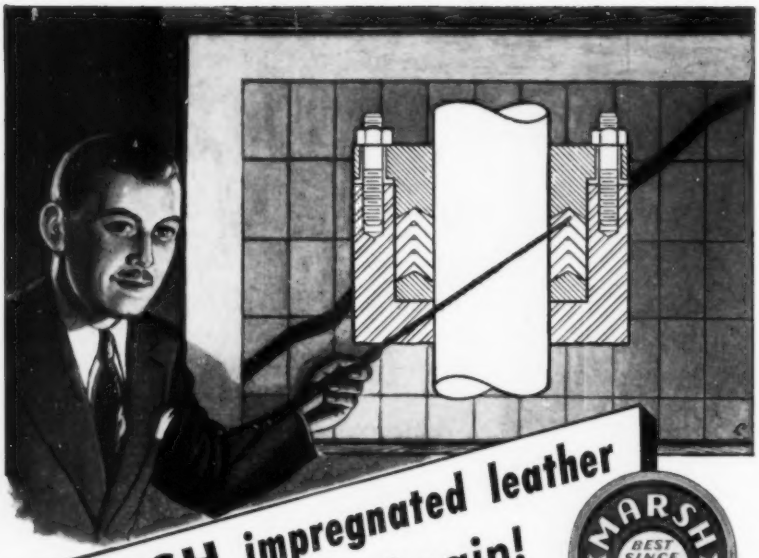

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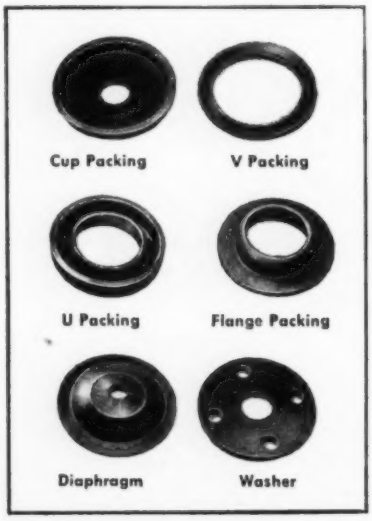

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Stresses, Their Measurements and Their Effects on Structural Parts", Symposium on the Failure of Metals by Fatigue; Melbourne University Press). The cylinder under study is fitted with twelve wire resistance strain gages; six gages positioned in the longitudinal direction and six gages in the hoop direction. All the gages are then wired to an insulated ring on the end of the cylinder.

The cylinder is then bored away in successive steps of 0.050 in. on the inside diameter. Hoop and longitudinal strains are measured after each step.

Where

E = modulus of elasticity
μ = Poisson's ratio
A_o = initial cross-sectional area of tube
A = area of bore following machining cut
d = incremental change in values per step of machining
r_l = longitudinal residual stress
r_h = hoop residual stress
s_l = longitudinal strain
s_h = hoop strain

$$r_l = \frac{E}{1-\mu^2}\left[(A_o - A)\frac{d(s_l + \mu s_h)}{dA} - (s_l + \mu s_h)\right]$$

$$r_h = \frac{E(A_o - A)}{1-\mu^2}\left[\frac{d(s_h + s_l)}{dA} - \frac{(s_h + \mu s_l)}{2A}\right]$$

Where

R = ratio of outside diameter to inside diameter
p_u = internal pressure at elastic limit of the material
f_y = yield point of material when tested in tension at 0.01 percent offset

the pressure required to cause the elastic limit to be exceeded can be found from

$$p_u^2\left[\frac{R^2}{R^2-1}\right]^2 + p_u\left[\frac{R^2}{R^2-1}\right]r_h - \frac{r_l^2 + r_h^2 - r_l r_h - f_y^2}{3} = 0$$

It is stated that confirmation of these formulas has been made in a number of tests on actual cylinders with and without residual stresses. These tests showed that the method could be relied upon to within 10 percent. In one instance, if no allowance had been made for the residual stresses, the critical pressure calculated by the conventional Lame formula would have been overestimated by 77 percent.

A test is also cited to indicate the beneficial results of autofrettage. The distribution of residual stress in an autofrettaged cylinder as found by the Sachs method was almost entirely compressive and reached a maximum of more than 200 percent greater than that obtained in a cylinder not autofrettaged. In this instance, it was not

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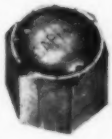

CAPLOC
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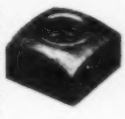

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possible to test the cylinder to determine the pressure at which the cylinder would break down elastically, since this pressure was higher than that which could be attained with the equipment available.

Although the residual stress does not affect the bursting pressure, since this stress is removed by the yielding that takes place after the elastic limit is passed, the discussion is supplemented by some pertinent comments concerning the results obtained when using some conventional bursting pressure formulas.

Tension Testing At Subatmospheric Temperatures

Abstracted from "Apparatus for Tension Testing at Subatmospheric Temperatures" by E. T. Wessel and R. D. Olleman, *ASTM Bulletin*, January, 1953.

DATA FROM TESTS at low temperatures are necessary in solving service application problems, in the determination of transition temperatures, and in fundamental studies of the behavior of metals at low temperatures. Coupled with the need for these data is the problem of developing apparatus with which these tests can be performed.

General requirements for testing apparatus: (1) The temperature range in which tests can be performed should be as broad as possible; (2) the equipment should be capable of reaching predetermined temperatures accurately, and it should be able to maintain these temperatures during testing, (3) the test temperatures should be reached and maintained with a minimum of manipulation, inconvenience, time expenditure and cost; and (4) the test procedures should not introduce any unwanted variables in addition to those already present in standard tension tests.

An examination of the literature shows that existing methods and equipment do not meet one or more of these requirements. In most of these methods, the specimen is cooled by direct addition of refrigerant to the bath, or by passing the refrigerant through a coil immersed in the bath. All applicable liquids have a limited useful temperature range as defined by their boiling and freezing points.

It is possible that the various liquid media now being used for low-temperature testing have a considerable effect on mechanical properties. It has been shown, using hardened tool steel bend specimens 1.0 x 10.0 mm in cross-section, that strength can be effected as follows:

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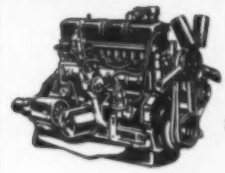

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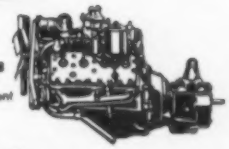

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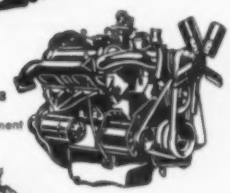

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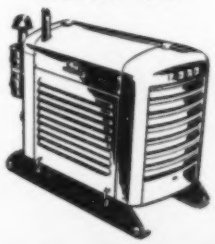

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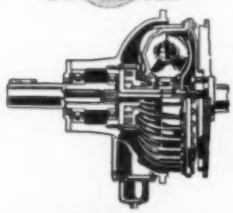

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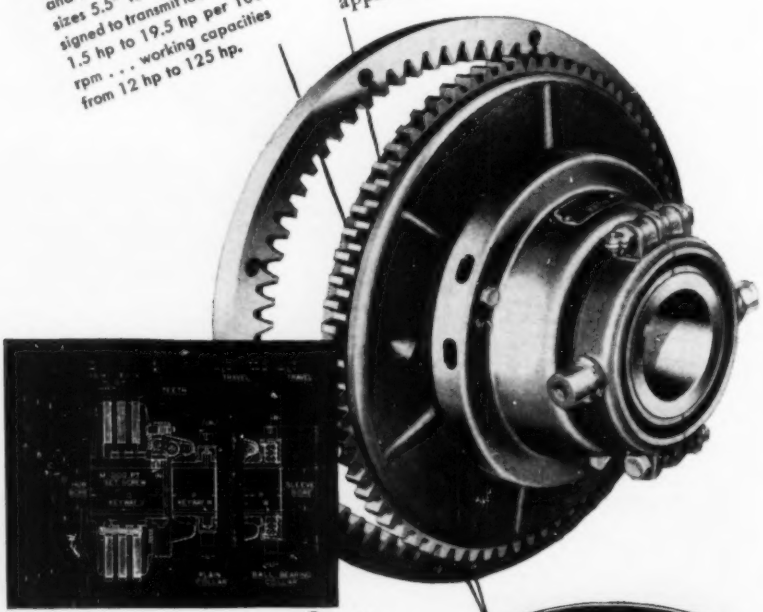

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Water	−22
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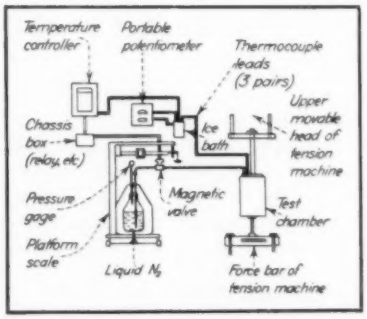
1.0 percent NaOH solution	+15
Petroleum	+27
Benzine	+18
Hexane	+17
Rust protectives	up to + 30

A new apparatus, using nitrogen vapor as one testing medium, is made up of three essential components: the refrigerant and supply system; the refrigerant flow-regulating system; and the testing chamber.



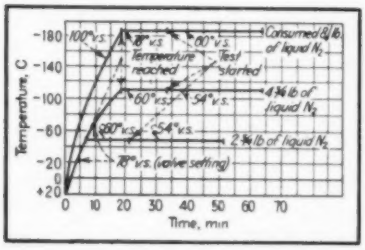
APPARATUS for maintaining constant subatmospheric testing temperatures.

The storage and supply system consists of a standard 25-liter Dewar flask equipped with a special head assembly. The essential parts of this assembly are: a pressure gage; a relief valve; an exhaust valve; and a ¼ in., slow-opening, packless needle valve with an indicator wheel. The flask containing the refrigerant traps the vapor evolved, and builds up a pressure on the surface of the liquid. This pressure is adjusted by the pressure relief valve, which maintains a constant supply pressure on the surface of the liquid nitrogen. This pressure forces the liquid up through the supply tube, with the flow regulated by the needle valve installed in the supply line.

The flow-regulating system consists of: the needle valve; a small packless magnetic valve; a 0-10 mv, continuously recording, self-balancing, potentiometer-type temperature controller; and a control thermocouple installed on the specimen in the test chamber. Two additional thermocouples also check temperature distribution. When more refrigerant is needed in the test

chamber, the controller opens the magnetic valve, allowing the nitrogen to flow at a rate set by the needle valve.

The test chamber is a double-walled, insulated copper can with a smaller can as an inner liner surrounding the test specimen. A commercial preparation, Sil-O-Cel, is used as insulation between the two walls of the outer can, and the outer can is jacketed with a ¾ in. felt wrapper. The refrigerant, in the form of vapor, enters the test chamber through a coil wound around the head of the top grip and escapes into the inner liner through the perforations in the bottom segment of the coil. In addition to dispensing the cold vapor, the coil extracts heat coming in through the top grip, and prevents conduction of heat to the specimen. After escaping through the perforations in the bottom coil segment, the cold vapor passes down over the specimen and lower grip and out the open bottom of the inner liner. This vapor will tend to remain in the bottom of the test chamber until forced up by the colder, dense vapor. The vapor is exhausted from the test chamber through a slightly oversized hole in the lid where the top grip enters. As the gas passes out around the top grip it extracts heat that would otherwise be conducted into the test chamber. As a result of this directed vapor flow, the heads of the top and bottom grips, the specimen, and the inner liner are all kept at very nearly the same temperature.



TYPICAL TIME - TEMPERATURE CURVES for subzero tension tests.

In general, this testing system is simple and does not require highly trained personnel for operation. Tests can be conducted at any temperature in the range from just below room temperature to −195.6 C, with the possibility of lowering this bottom limit to the temperature of liquid helium, −268.6 C. The effect of testing media is minimized because the dry nitrogen vapor used as a cooling medium is about the same as air, and low-temperature test results are comparable to data from tests made in air at elevated and room temperatures.

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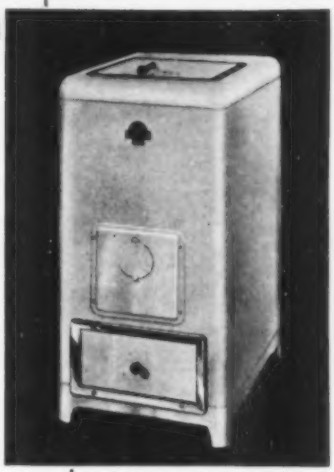
W.M. Milbourne, Sales Mgr., Calcinator Division Valley Welding & Boiler Co., Bay City, Michigan



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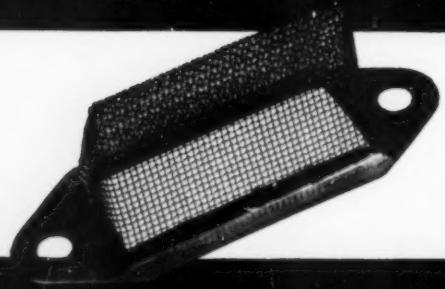

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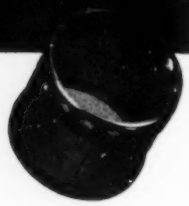

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OUR READERS SAY

Solution of the Cubic Equation

To The Editor:

Since publication of my article "Solution of the Cubic Equation By a Simplified Procedure," page 183, September 1952, *Product Engineering*, I have learned that a pamphlet entitled "Pocket Tables for Cubics" was published in 1933 by David Katz of Wilmington, Delaware. If I had known of the existence of this pamphlet when writing my article, I would have mentioned it just as I did the unpublished notes by W. V. Lyon.

Although there are differences in terminology, scope and arrangement of the data supplied for arriving at solutions, the Katz method and my method yield identical real roots for cubic equations. In addition, my method and tables yield the complex roots.

The pamphlet published by Mr. Katz is a valuable contribution to the mathematical literature dealing with methods for finding the roots of cubic equations. —ENNIS E. JONES, *Minneapolis, Minn.*

Has Oil Leaks Around Threaded Holes

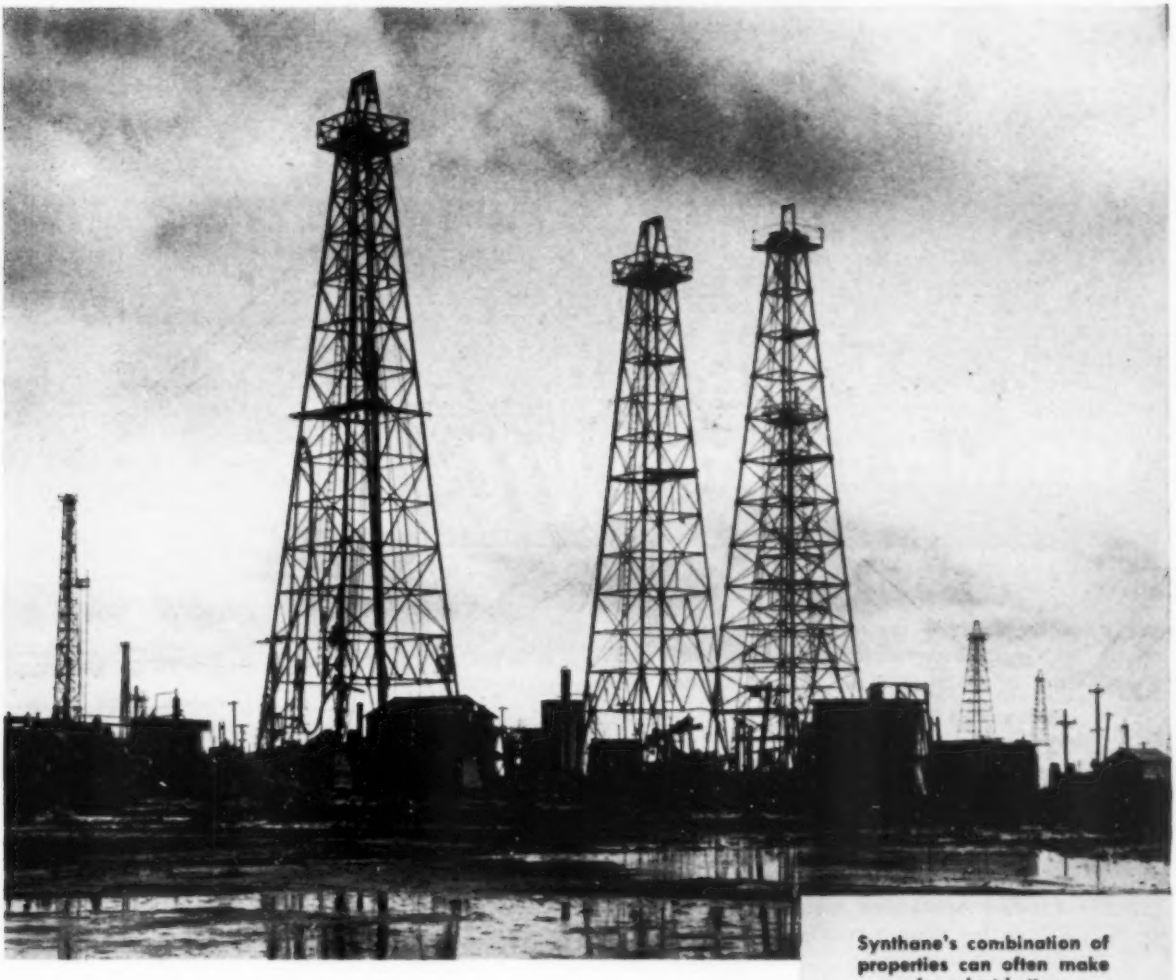
To The Editor:

Is it possible that your publication, which I receive, has a department which helps with special manufacturers' problems? We have one which may be solved in some other industry, but which has dogged us for a number of years.

In shipping certain equipment, we would like to flood the interior with oil to prevent corrosion. However, this oil leaks out and we have the choice of plugging all openings with a good many expensive pipe plugs, or draining out most of the oil and trusting that the residue will protect the surfaces.

We have tried to plug the openings with masking tape, corks, and plastic thimbles, but there is always leakage through the tape or past the threads.

Do you know of some different way of sealing threaded holes in cast surfaces so that a fluid can be contained without leakage? The method should



From crude to crankcase— with an assist by SYNTHANE

Without oil there'd be no automobiles or airplanes, fewer plastics, soaps, drugs, floor polishes, cosmetics, insecticides.

In one form or another, petroleum and petrochemicals are almost as important to us as the air we breathe. And in one way or another, Synthane plastic laminates are equally important to petroleum production and processing.

The reason is understandable. Synthane is a dependable material with many uses.

Because it is wear-resistant and tough, yet easy to machine, Synthane is used for components of oil well cementing equipment. Because Synthane is strong and corrosion-resistant, it is excellent for pump valves, piston rings, and compressor plates in tank-farms and refineries. Because it is a good insulator, Synthane in the form of flange insulation provides cathodic protection for pipe lines. Because it is a good moisture-resisting dielectric, light weight Synthane is used in geophysical survey equipment and oil-locating instruments. Wear-and-corrosion resistance make Synthane desirable for flow-line valve-seat inserts.

Because of all these valuable properties, plus many more, Synthane may be a material you can put to profitable use. To find out, get the complete Synthane Catalog. Write to Synthane Corporation, 6 River Road, Oaks, Pennsylvania.

Synthane's combination of properties can often make a good product better.

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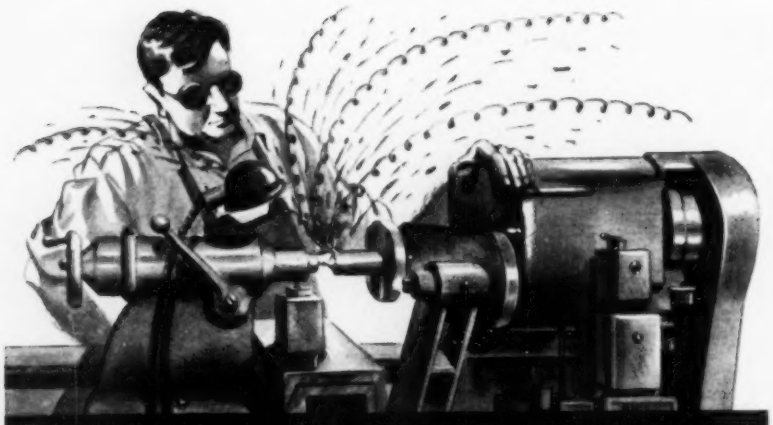
Resists moisture, oil, solvents, and corrosive atmospheres.

Synthane-one of industry's unseen essentials

SYNTHANE

LAMINATED PLASTICS



SECONDARY OPERATIONS NIL!

Manpower . . . machinery . . . technical skill—these are the wastes of many companies adapting inflexible standard components to meet the requirements of their applications.

Sometimes they buy standard components and struggle to build systems around them, thus limiting the efficiency of their own designs. But more often they perform one or more secondary operations on the component to make it usable. The result is not only waste but loss of the component's "built-in" precision.

When you buy Transicoil components for servo systems, secondary operations are nil. You get a finished product . . . built for your particular application . . . and ready for immediate installation . . . with all the accuracy and efficiency for which it was designed.

Our technical catalog describes some of the precision Transicoil units which enable you to take full advantage of your servo system designs. Write for a copy today.

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be inexpensive, suitable for shipping and storage only. Any help you can furnish will be much appreciated.

—F. H. AINSWORTH,
The Wayne Pump Co.

Ed—Plastics have been used by a number of companies for plugging openings in castings or pipes to prevent corrosion and the entrance of dirt. Of course in the aircraft industry they have regular plastic caps and plugs to close up all of the pipe openings as the job progresses.

Recently, polyethylene plugs have been made available. They are really caps that slide over a glass stopper and then the stopper is pushed into a glass bottle. Some of the whisky manufacturers have used such stoppers for their bottles. But the procedure is to take out the cork stopper and then put in the polyethylene glass stopper which is of a fancy appearance.

You might possibly use a polyethylene coated cork stopper. This will simply be a tapered cork of the conventional size, but made slightly smaller so as to permit the polyethylene cap to slip over the cork. The tapered stopper would then be driven into the threaded openings.
We cannot guarantee that this will seal the openings perfectly, but it seems that it would, because the polyethylene would dig right down to the root of the thread and thereby close the opening completely.

Prefers Safe To Fast Automobile

To The Editor:

It made me very happy to read your editorial in the October issue of *Product Engineering* regarding current design trends of automobile manufacturers. I am glad to see that at least someone is taking a stand on this senseless race of manufacturers to put more power into their present fragile construction. It seems to me that our automobile manufacturers could devote their energies to producing a safe economical version instead of a monster for which our highways are totally unprepared.

Considering the fact that most of us spend most of our driving time at speeds considerably under our present capacities, why then must we have more power? All this extra power costs money to operate, and serves no good purpose. The fact that the automobile has killed more people than all our wars put together should serve as a deterrent to these leaders.

Could it be that these leaders have

Makes automotive dreams come true

In the automotive industry, as in countless others, OSTUCO Tubing has what it takes to transform drawing board dreams into practical realities—infinite adaptability, great strength, light weight, and low cost.

Here are a few applications in passenger cars, trailers, buses, and trucks: Steering post columns, shock absorbers, bumper guards, mirror and light supports, piston pins, connecting rods, bearings, bushings, radiator and tank fittings, exhaust parts, radius rods, seat frames, sleeves, axles, and carrier racks.

Leading designers and manufacturers in practically every field specify OSTUCO Tubing, seamless or electric welded, because OSTUCO manufactures, forges and fabricates all at one plant . . . and because OSTUCO is famous for consistent highest quality.

It will pay you to consult our experienced engineers about OSTUCO Tubing for your current needs or for redesigning your products to meet future competition.

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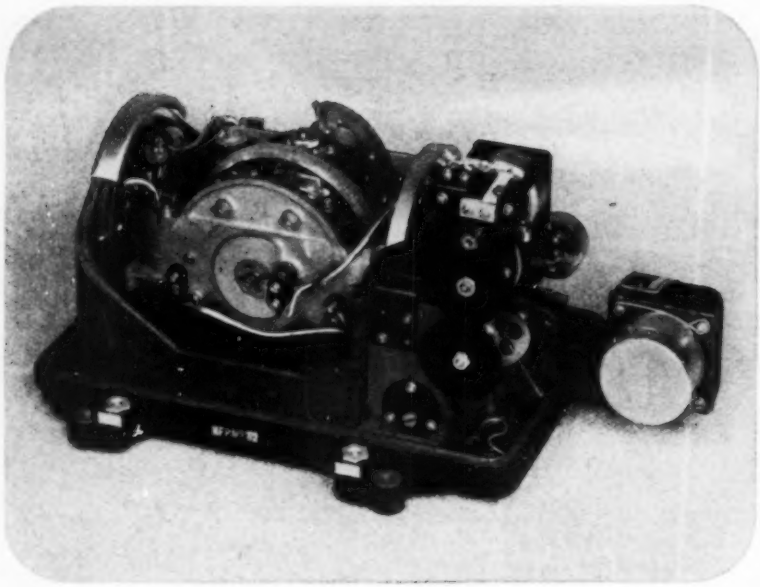

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Used in the precise caging mechanism which locks the gyro spindle in a predetermined attitude, Micro Ball Bearings measure up to every requirement for savings in friction, weight and space. Low friction is of particular significance, since the mechanism operates on only 12 watts (6 watts standby). The high durability of Micro bearings also assures long trouble-free operation, minimizing the problem of combat area servicing.

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- **More Sizes and Types** Available in 135 sizes and types down to .04" bore, ⅛" O.D. Materials include chrome, stainless steel and beryllium copper. Special items and materials considered.
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Free Catalog Send today for Catalog No. 53 which gives full specifications and application data on all types and sizes of Micro Ball Bearings.

observed an increase in our population and have decided to do something about it? Personally, I would prefer it to be their children and not mine when such a decision has been made by them.

These super-power cars would be far more practical if confined to such purposes as police cars and racing cars instead of placing such a formidable weapon within the reach of everyone.

—E. R. RAWSON

What Are "Mere Working Expenses?"

To The Editor:

As a subscriber of *Product Engineering*, I would greatly appreciate your advice on the following question:

On taking up the production of a new article one generally takes into consideration that the estimated price should be no more than ⅓ or ¼ of the sales price if the product is to be competitive. This ⅓ or ¼ respectively are the results of the costs of material, wages, and the mere working expenses. As the "mere working expenses" (or whatever the correct English term may be) may cover various costs which should better not be booked under this item, it would be of great interest to me to learn from you what exactly is to be understood as "mere working expenses" according to the habits of calculation in the U. S. industry.

—ROBERT VOGEL,
Hamburg, Germany

Ed—The question you proposed, namely, what in the United States is considered as "Mere Working Expenses" is a very difficult one to answer.

First of all, we can't agree with your assumption that the manufacturing price of the products should be no more than ⅓ or ¼ of the sales price. That depends entirely on the nature of the product. If it is an item such as a household appliance, which is in mass production, it is doubtful whether the manufacturer can count on the manufacturing cost being much less than 85 to 90 percent of *his* sales cost. Naturally, that does not take into consideration such factors as transportation nor distribution cost.

At any rate, the factor varies quite widely here in this country, and we are not sure exactly what you mean by the term "Mere Working Expenses." We would imagine that what you have in mind is the overhead, including salaries, advertising costs, sales promotion costs, materials handling costs,

Whenever circuits call for precision and high resolution in compact space...

There's a 10-turn Helipot to meet your requirements

With the development of the original HELIPOT—the *first* multi-turn potentiometer—an entirely new principle of potentiometer design was introduced to the electronic industry. It made possible variable resistors combining high resolution and high precision in panel space no greater than that required for conventional single-turn potentiometers.

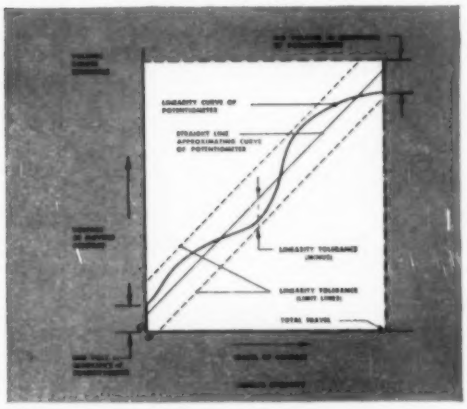
The Helipot Principle... *High resolution and precision settings require a long slide wire. But by coiling a resistance element into a helix, it is possible to gain desired resolution and precision without wasting panel space. This principle is applied in various Helipot models with slide wires ranging from 3 to 40 helical turns.*

Advantages are immediately apparent. In the case of the widely-used 10-turn Model A Helipot, for example, a 45" long slide wire—coiled into ten helical turns—is fitted into a case 1¾" in diameter, and 2" in length. Another advantage of the 10-turn pot is that, when equipped with a turns-indicating RA Precision DUODIAL, slider position can be read directly as a decimal, or percentage, of total coil length traversed.

10-TURN HELIPOT MODELS—CONDENSED SPECIFICATIONS

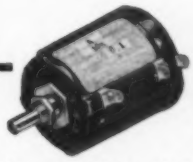
	Model A	Model AN	Model AJ
No. of turns	10	10	10
Resistance Range	10 ohms to 300,000 ohms	100 ohms to 250,000 ohms	100 ohms to 50,000 ohms
Resistance Tolerance: Standard	±5%	±5%	±5%
Best	±1%	±1%	±3%
*Linearity Tolerance: Standard	±0.5%	±0.5%	±0.5%
Best	±0.05% (1K ohms and above)	±0.025% (5K ohms and above)	±0.1% (above 5K ohms)
Power rating @ 40°C	5 watts	5 watts	2 watts
Mechanical Rotation	3600° +4° −0°	3600° +1° −0°	3600° +12° −0°
Electrical Rotation	3600° +4° −0°	3600° +1° −0°	3600° +12° −0°
Starting Torque	2 oz. in.	1.0+.3 oz. in.	.75 oz. in.
Running Torque	1.5 oz. in.	0.6+.3 oz. in.	.50 oz. in.
Net Weight	4 oz.	4 oz.	1 oz.

*i.e. INDEPENDENT LINEARITY. The above linearity tolerances are based on the following definition recently proposed to clarify and standardize nomenclature related to precision variable resistors. . . . "Independent linearity is the maximum deviation in percent of the total electrical output of the actual electrical output at any point from the best straight line drawn through the output versus rotation curve. (This line shall be measured through the extent of the effective electrical angle.) The slope and position of the straight line from which the linearity deviations are measured must be so adjusted as to minimize these deviations."



10-Turn Helipot Highlights

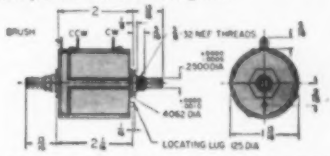
From the basic Helipot principle, model variations have been developed to meet new requirements:



Model A Helipot

the original 10-turn Helipot—provides a resolution from 12 to 14 times that of conventional single-turn potentiometers of same diameter (1¾"), linearities as close as ±0.05% in resistances as low as 1K ohms.

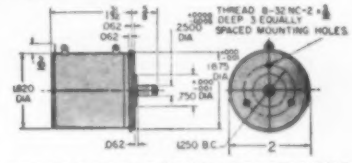
The same multi-turn principle is also available in 3 turn units (Model C), and larger-diameter units of 15 turns (Model B), 25 turns (Model D), and 40 turns (Model E)—a type for every application from 5 ohms to 1 megohm.

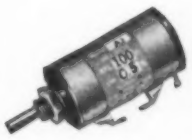


Model AN Helipot

an ultra-precision version of the basic 10-turn Helipot. Produced in volume to extremely close electrical and mechanical tolerances, this unit features precision ball bearings (Class 5), servo mounting lid, plus linearity tolerance as close as ±0.025% as low as 5K. A 3-turn unit (Model CN) is also available.

Models AN and CN are particularly recommended for precise servo-mechanism applications and represent the most advanced design and highest quality available today in the field of precision potentiometers.

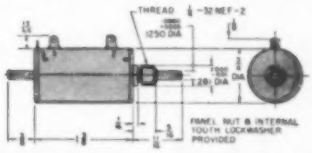




Model AJ Helipot

a 10-turn *miniature* Helipot only ¾" in diameter, weighs 1 oz., has slide wire 18" long. Also available with servo mounting (Model AJS) and servo mounting with *ball* bearings (Model AJSP). Linearities as close as ±0.1% as low as 5K.

Designed for long life under severe operating conditions, the AJ Series is widely used where small size and weight are vital.



Design details on above units are subject to change without notice. Certified drawings available upon request.

Only Helipot is able to supply—in volume—multi-turn helical potentiometers *with special features to meet your particular needs* . . . Special Shafts, Extra Spot Welded Taps at any position, Ganged Assemblies (except AJ), Special Temperature Coefficients, etc. Send us your requirements!

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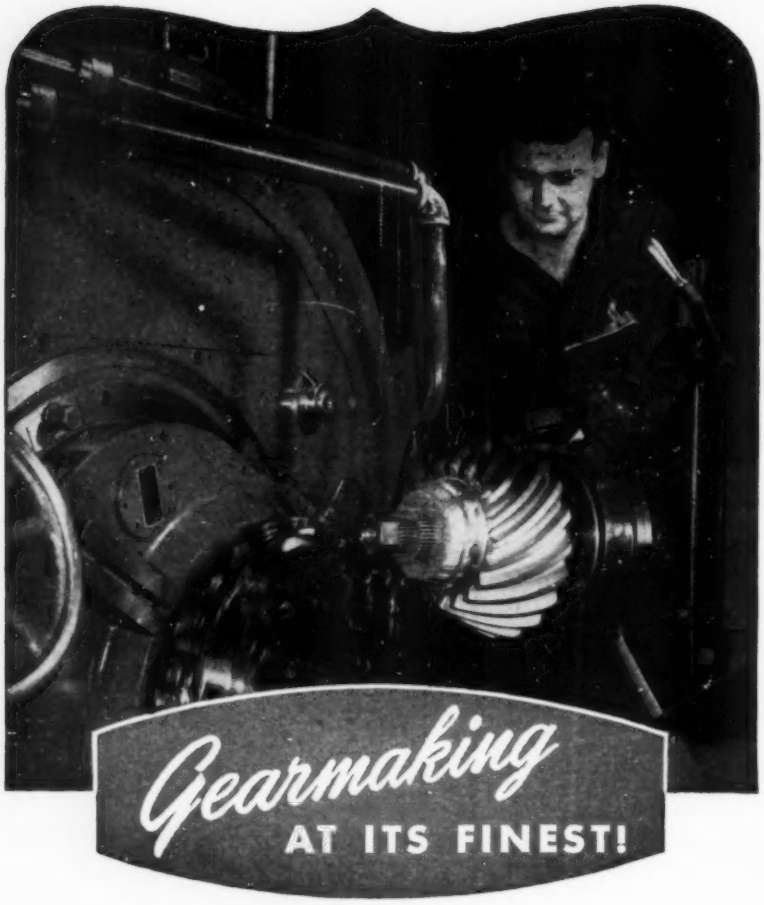

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and machine and plant amortization. Most companies in this country also reserve for research and development a percent of net income ranging anywhere from 1 to 5 percent for any given year.

It is rather difficult to answer your questions without writing at least two or three chapters of book length; however, perhaps some tearsheets of past articles in *Product Engineering*, which we are forwarding to you, will give you an idea of current practices.

Knows Reason For Engineer Shortage

To The Editor:

Regarding an article in *Product Engineering*, January 1953, page 197, titled, "Stretching the Supply of Engineers," there seems to be a general, national trend to ignore the *real* reason for the so-called "Shortage of engineers." That real reason, as you undoubtedly know, but also ignore, evidently is low pay. There are no pay incentives at all, although most hourly paid employees get bonuses, and a lot of them, such as draftsmen, machinists, and others that engineers direct, even get more pay than the engineers!

No wonder there is a shortage, and it will be worse, much worse, unless the above situation is speedily corrected. —DEAN L. BRANDS

Square Root Extraction

To the Editor:

Here is a method for extracting square roots on an automatic calculator. Although it is not as rapid as Friden's square root machine, I believe it does have merit. Having shown it to a number of people, I am not certain whether their surprise at the simplicity of the method, or my surprise that it was new to everyone was the greater.

(1) Point off the number in blocks of two, starting at the decimal point. Then forget the decimal until time to point off the answer.

(2) Estimate the square root of the first block, or the first two, and divide the original number by this estimate.

(3) Average the trial divisor and quotient for a second trial and repeat until the desired degree of accuracy is attained.

Here is how it works for an integer and a decimal:

a) Example No. 1 267.09
b) Point off 2'67.09

A Customer Reports:

"We use Continuous-Cast Bronze because of its Uniform Quality"

MANNING, MAXWELL & MOORE, INC., (Shaw-Box Crane and Hoist Division) Muskegon, Michigan, manufacturers of cranes, hoists and specialties, says also that ASARCO bronze lends itself admirably to production on automatic screw machines.

ASARCO Continuous-Cast Bronze is used for the gear center of the brake gear in this company's "Budgit" portable electric hoist because its high physical properties far exceed those of ordinary foundry or mill products. Stock is consistently uniform in size and quality. Porosity is non-existent.

Since the patented ASARCO continuous casting process excludes sand, dirt, dross and other impurities, there are no inclusions in ASARCO bronzes to injure tools or reduce high cutting speeds. Rejects are virtually unknown . . . machining on automatics is standard practice.

All stock for machining is Medart-straightened and furnished within a general tolerance of +0.004" to —0.006" on outside diameters. Tube concentricities are within 1.5% of wall thickness.

Continuous-Cast Bronzes are made to order in a wide variety of alloys . . . in standard lengths of 12' . . . lengths 5' to 12' on request . . . lengths 12' to 20' by special arrangement.

216 sizes and shapes of standard Asarcon 773 bearing bronze (SAE 660) are stocked in 105" lengths for convenience at warehouses in principal cities across the country. Distributors will cut this stock long or short to suit your needs.

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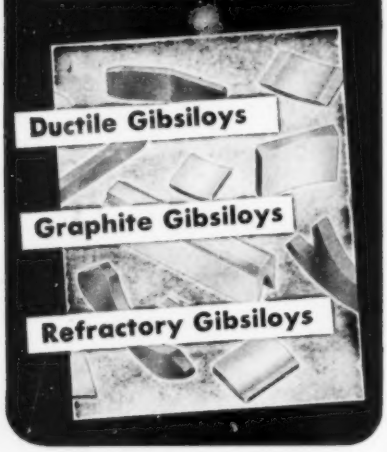

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c)	Estimated root*	16.0
d)	Forgetting the decimal	16
e)	First trial divisor	16
f)	First quotient	16693
g)	Average (e) and (f)	1634
h)	Second quotient	163458
i)	Average (g) and (h)	163429
j)	Third quotient	1634288
k)	Desired square root	16.343

* $16^2 = 256$, $17^2 = 289$

a)	Second example	0.00074952
b)	Point off	.00'07'49'52
c)	Estimated root†	.027
d)	Ignoring the decimal	27
e)	First trial divisor	27
f)	First quotient	27760
g)	Average (e) and (f)	2738
h)	Second quotient	2737472
i)	Average (h) and (i)	2737736
j)	Third quotient	2737736
k)	Desired square root	0.027377

† $25^2 = 625$, $30^2 = 900$

—HENRY C. GRAY
Falk Corporation

ERRATA

December 1952, page 196, *New Low-Cost Process Turns Titanium-Oxide Into Titanium.* Middle of third column—"the metal has a purity of 0.992 to 0.995 percent." Should read "99.2 to 99.5 percent."

December 1952, page 217, *Using Taylor's Series to Solve Spiral Gear Problems.* Top of second column—in the second equation for f (x), the factor h in the last term should be squared.

January 1953, page 199, *50,000 Ton Closed Die.* In describing the Air Force's heavy press program, we neglected to mention Loewy Construction Co., Inc. as the manufacturers of the new hydraulic press. Producing large forgings and extrusions from various metals, the press requires a foundation having a depth of 100 ft., with supporting walls from 6 to 13 ft. thick.

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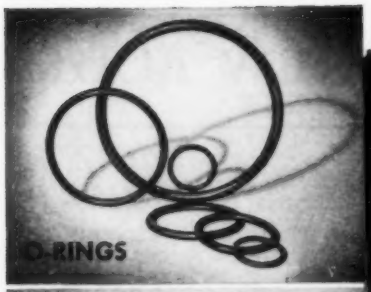

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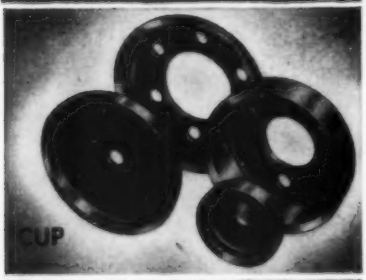

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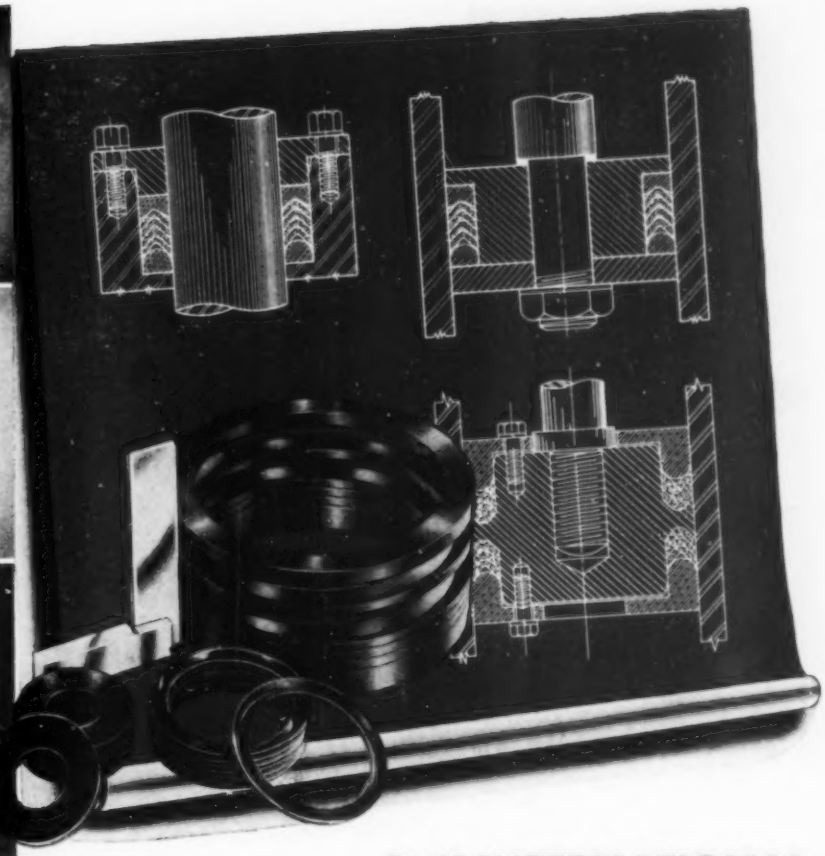

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NEW BOOKS

Industrial Handbook of Photographic Methods

7¾ x 9 in., published by the Eastman Kodak Company, 343 State St., Rochester 4, N. Y. $0.50 per section.

This is a collection of technical information on the materials, processes and techniques associated with industrial photography. It is made up of four separate sections assembled in O ring-binder form for easy expanding with additional data that is now available as well as that which will become available in the future.

These sections which discuss application of photography of general industrial interest are:

(1) How to Use Reproduction Materials
(2) Microfilming with Kodograph Micro-Film Equipment and Materials
(3) Photography Through the Microscope
(4) Making Service Pictures for Industry.

Other publications on industrial photography that are currently available from the Eastman Kodak Company are listed on the introductory pages.

Servomechanism Analysis

GEORGE J. THALER, *Asst. Prof. of Electrical Engineering, U. S. Naval Postgraduate School and* ROBERT G. BROWN, *Senior Project Engr., A. C. Spark Plug Div., General Motors Corp., 6 x 9 in., 414 pp., Published by the McGraw-Hill Book Co., 330 West 42 St., New York 36, N. Y., $7.50.*

Beginning with a discussion of the background of automatic controls, the authors present the essentials of the mathematical theory of servomechanisms. They stress the elements of analysis as being a necessary prerequisite to design.

The Laplace transformation, which is discussed in detail, is used exclusively as a mathematical tool since it is suitable both for the solution of the differential equations involved and for the construction of transfer functions. The transfer function of a system can be arrived at very simply from the Laplace transform of the differential equation by assuming the system to be initially at rest and thus providing that all initial conditions are zero. Doing this, eliminates inter-

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**N2B-2	.....	7	2	30	1800
N3C-1	.....	10-15	1	1000	20,000
†N3E-2	.....	7	1	90/150	1800
N5B	8 watts	20/40	1	1000	5000
N6A	20 watts	40/80	1	1000	5000
N6B	60 watts	30	1	400	8000

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mediate labor if both transfer-function data and differential-equation data are desired.

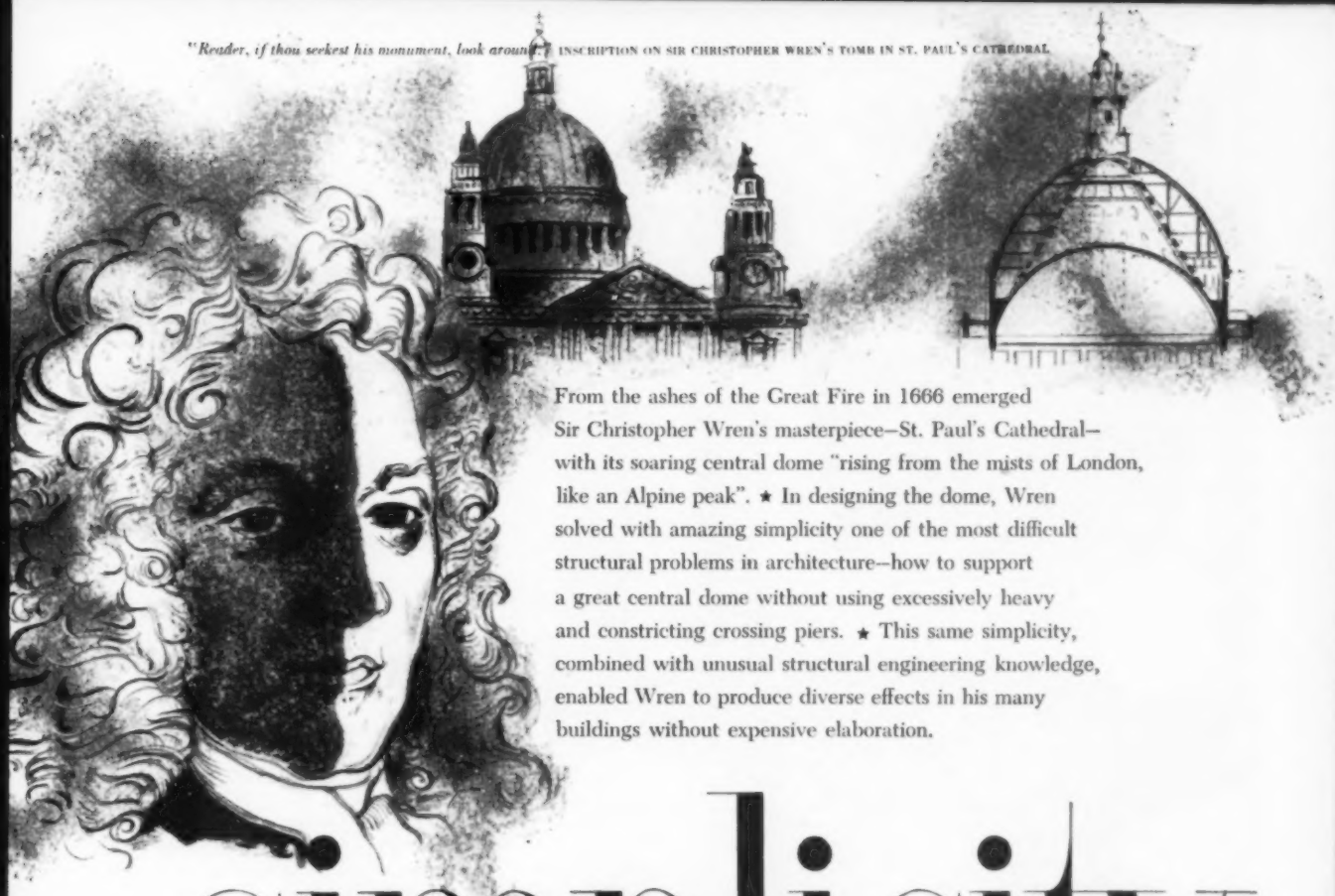
It should not be assumed that the transfer-function method is in itself sufficient for servomechanism analysis and design. Several important characteristics of servomechanism performance, such as the response time and the maximum deviation of the output, cannot be calculated with great accuracy except from the differential equation, though they may be estimated fairly well from the transfer-function data. Thus, for complete quantitative information on a servomechanism both the differential-equation solution and the transfer-function solution are desirable: the transfer function for ease in calculation and design, the differential equation for exact performance data on several important characteristics of the system. The transfer-function approach is normally the best starting point, since it permits rapid calculation of most of the desired information within reasonably close limits. The differential-equation solution would be attempted only if the specifications of the system required the information or if the desired performance could not be checked closely enough from the transfer-function data.

To facilitate setting up the differential equations for various systems, the authors devote considerable space to the use of electrical analogies of mechanical, thermal, hydraulic and pneumatic systems as well as electromechanical machinery. Following this, the differential equations of some basic servomechanism systems are derived, solved and the solutions analyzed. Only simpler cases are considered, since they illustrate the fundamental principles involved without introducing mathematical complications or other factors which would detract from the points being stressed. However, most of the important variations are treated in adequate detail.

Two special features of the text exemplify recent developments in servo theory. One of these is a discussion of Relay Servomechanisms. These differ from continuous-control servos in the nature of the unit which applies the power (source) to the output member. Block diagrams for the two may be identical since many of the same components are used in either type of system. However, relay servos commonly have electromagnetic relays which apply full power to the output whenever the error exceeds some given magnitude and maintain full applied power until the error is reduced.

The other outstanding feature is the

"Reader, if thou seekest his monument, look around." INSCRIPTION ON SIR CHRISTOPHER WREN'S TOMB IN ST. PAUL'S CATHEDRAL



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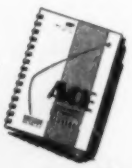

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Root Locus Method which is a convenient means of computing the transient response from the transfer function equations. This discussion stresses the promise offered for future developments in the analyses and design of dynamic systems through the concept of the pole and zero configurations.

The appendixes contain a quantity of factual information on the theory, construction and application of servo components which have not previously been collected into one book.

Electronic Analog Computers

GRANINO A. KORN, *Staff Engineer, Lockheed Aircraft Corp. and* THERESA M. KORN. 6 x 9 *in.* 378 *pp. Published by the McGraw-Hill Book Co., 330 W. 42nd St., New York* 36, *N. Y.* $7.

D-c analog computers are relatively simple electronic devices now commonly used to solve a variety of problems in applied mathematics. Their application to the design of modern automatic control systems has been particularly interesting and successful: The authors have presented their work to satisfy the growing need for a book on this new subject. The techniques they describe have become well established during the last five years. Although interest in this field is growing, many engineers lack access to reliable sources of technical information. Moreover, many who do know the details of computer design lack experience in intelligently applying the new techniques to their problems. There are, in particular, the questions of how to set up problems on a computing machine and how to administer a computer installation.

No mathemaitcs beyond that taught in an elementary course on differential equations is required. The large amount of material which had to be covered made it impossible to add a chapter on elementary electronics; the reader is, instead, referred to good elementary texts on this subject.

Chapter 1 is an introduction to d-c analog computers. The reader will find the following technical chapters more useful if he is first given an opportunity to see the picture as a whole. Accordingly, this briefly treats the applications of computing devices, the mathematical relations involved, and the techniques used, with the object of gaining an over-all view of the subject.

Chapter 2 attempts to teach a simple, standard procedure for setting up a d-c analog computer to solve a given

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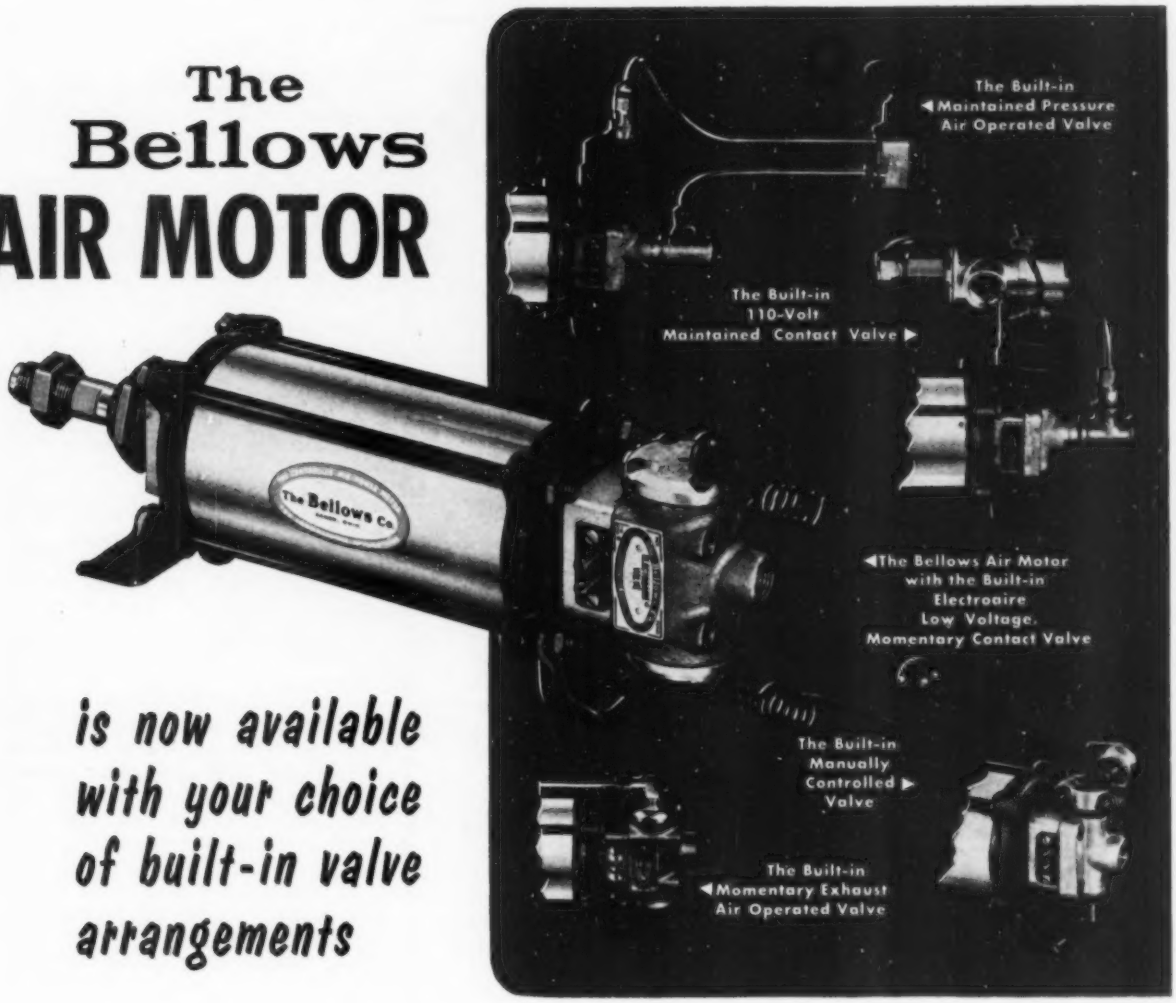

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set of differential equations. The procedure described has proved useful in several years of practical work.

The principles underlying the operating of analog computers are essentially simple. On the other hand, the authors have worked with computer operators in various parts of the country, usually men with degrees in engineering and mathematics, and have seen many others at work. Many of these people had fine backgrounds ranging from electronics to relativity theory. Thus, although they were new in the computer field, they learned the principles very quickly. But their chief difficulty was in the determination of scale factors, particularly where changes of the time scale are involved. Therefore, every effort has been made to present this subject in detail. All sections in this chapter have been documented with practical examples.

Chapter 3 presents computer setups for a number of practical problems which serve as illustrations of modern industrial d-c analog-computer applications. The preparation of useful records of each computation is particularly stressed. It is intended that the samples of problem-preparation records shown will be useful for reference.

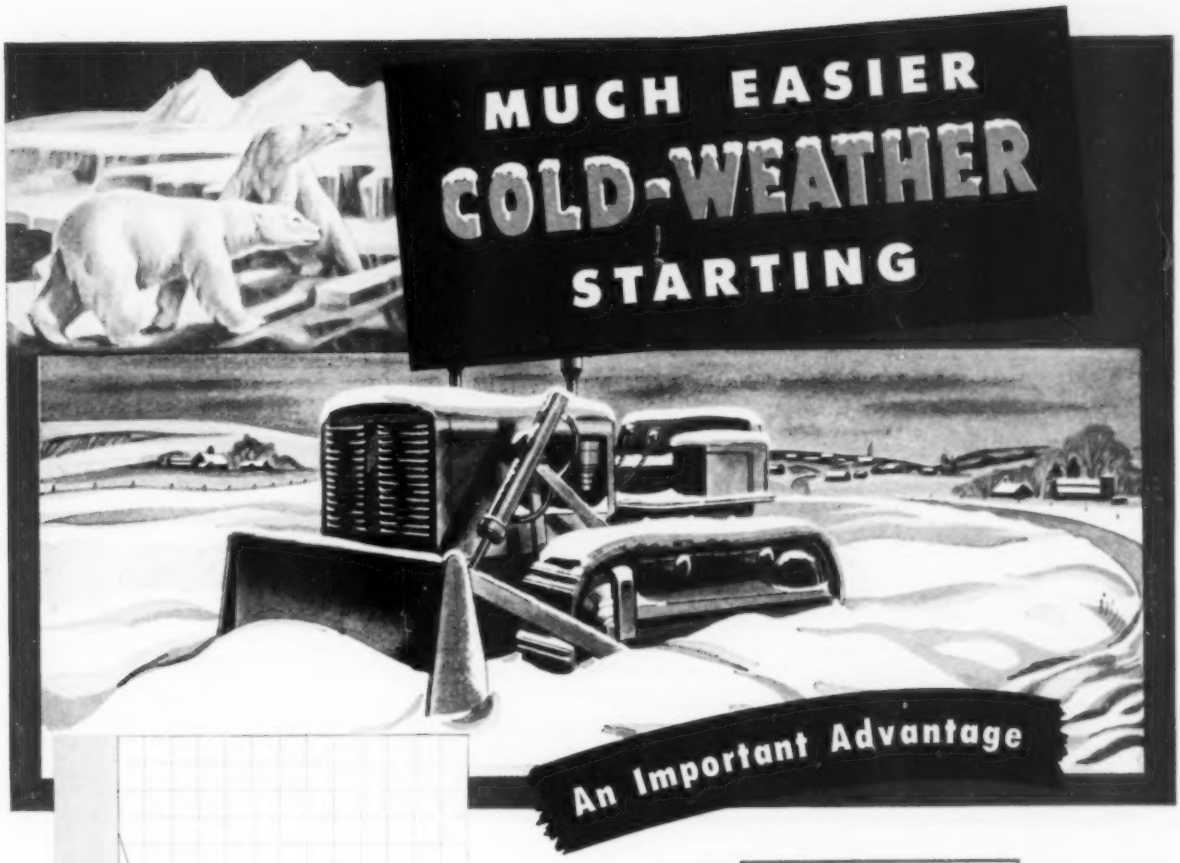
Chapters 4 to 6 describe the design of electronic computing elements for maximum accuracy, according to the best modern engineering practice. Some of the more technical parts of the accuracy analysis have been placed in the Appendix for the convenience of the reader.

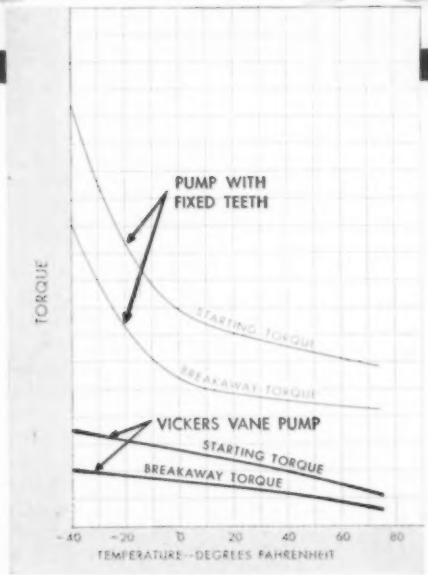
Specifically, Chapter 4 describes the design of the networks and feedback circuits used to perform the mathematical operations of addition, multiplication by constant coefficients, differentiation, and integration, with special emphasis on the design of accurate d-c integrating devices.

Chapter 5 deals with the design and operation of modern d-c amplifier circuits for computer applications. A discussion of the stabilization of high-gain feedback amplifiers is included. Automatic balancing circuits are described, and the actual circuit diagrams of many d-c amplifiers used in modern d-c analog computers are presented.

Chapter 6 discusses developments in the still open fields of analog multiplication and function generation. Several previously unpublished schemes for multiplication and function generation are discussed.

Chapter 7 describes the design of the auxiliary components, such as power supplies and recorders; two complete sections are devoted to a dis-





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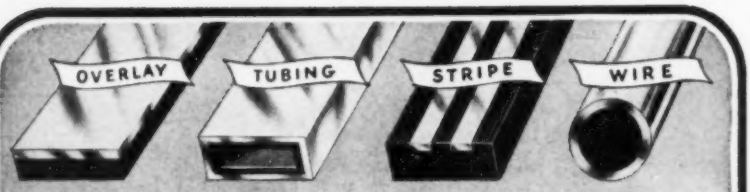

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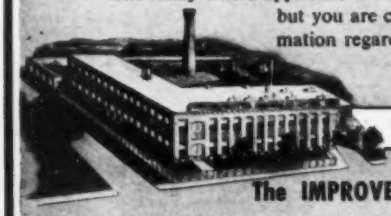

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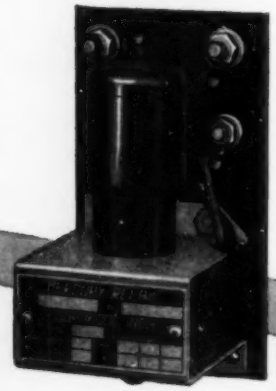

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cussion of improved control circuits. The remaining portion of this chapter deals with procedures for operating and checking d-c analog computers.

Chapter 8 describes the design and construction of complete computer installations for various applications in industry and science. The choice of computing elements and associated equipment is discussed, with emphasis on reliable and economical operation. Detailed descriptions of several modern installations are given, and these are discussed in the light of the design principles previously presented.

Power Plants for Aircraft

JOSEPH LISTON, *Prof of Aeronautical Engineering, Purdue University.* 6 x 9 *in.* 577 *pages. Published by McGraw-Hill Book Co.,* 330 *West* 42*nd St. New York* 36, *New York* $8.50.

A text for the undergraduate student in aeronautical and mechanical engineering, the emphasis is on fundamental principles, and involves the consideration of all types of aircraft power plants.

Included are comprehensive comparisons of the many types of jet and reciprocating power plants, a fundamental analysis of the theoretical power plant cycles, a comparison of actual engine performance with the theoretical cycles, and a discussion of some of the practical problems encountered in operation and testing.

Almost all the new advances in the field that have been declassified are discussed, and within the limits of government restrictions, the book considers the basic principles of reciprocating engines, turbo jets, turbo props, ramjets, rockets, and potential nuclear types. Review questions and problems are included at the end of each chapter.

Chapters cover: basic requirements and achievements; utilization of available energy; fuels; charge handling; cylinder and burner phenomena; performance; turbine engine characteristics; and structural and mechanical requirements.

A large number of illustrations, diagrams, charts, examples, and review questions are included.

Relay Engineering

CHARLES A. PACKARD, *Chief Engineers, Struthus-Dunn, Inc.* 640 *pages,* 5 x 7 *in. Published by Struthus-Dunn, Inc., Philadelphia, Pennsylvania,* $3.

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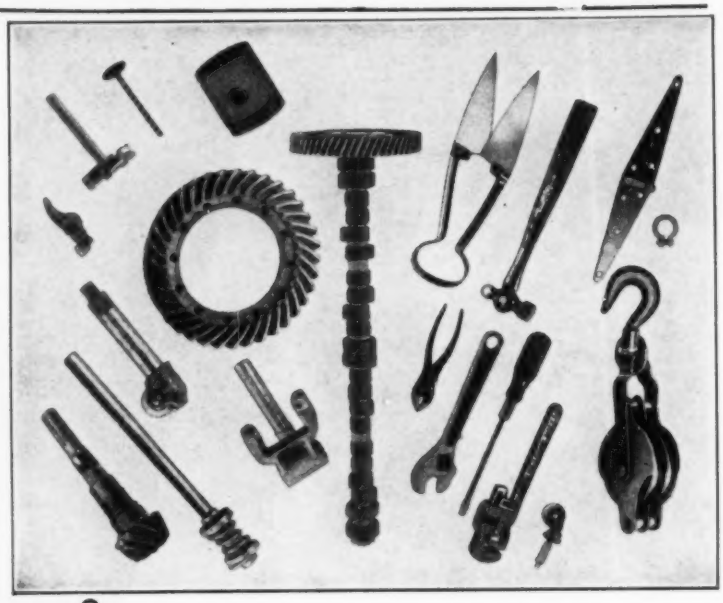

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Scale of production	Large or small volume; large or small work
Method of application	Dip Barrel tumbling, racked or basketed work
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Bath Temperature	190° - 205°F.
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plication, and who must determine the circuits in which they are to be used, requires a variety of information that has never been gathered into one volume. This book attempts to fill this need. The information is treated in a practical manner and theoretical discussions have been omitted or reduced to the minimum necessary for understanding the text.

In the majority of system wiring diagrams, a rectangular box has been shown to indicate the load on the relay, thus making the application intentionally vague. The designer can substitute meters, solenoids, valves, warning signals, lamps or whatever other device he is interested in controlling. In this manner, the systems can be made to apply to a large number of specific problems.

The manual is divided into the following sections:

(1) Selection of a relay for a specific task. This section covers the details of selecting specific types of relays that should be used, once all the requirements of an application have been determined.

(2) Applications and circuits. This section includes a large number of typical simple and complex relay circuits. Usually there are a number of circuits which can be used in any one application. The material covered here helps the designer to select the simplest system which will satisfy his needs.

(3) Relay components. This section covers the mechanical and electrical details of specific relays. In particular, it covers relay coil requirements, and outlines several considerations involved in selecting wire size, coil resistance, and the number of turns in a coil necessary to secure operation differing from standard conditions.

Auxiliary equipment, installation, maintenance, testing and testing equipment are also treated.

Basic Electronic Test Instruments

RUFUS P. TURNER, *Registered Professional Engineer, 254 pages, 6 x 9 in. Published by Rinehart Books, Inc., 232 Madison Ave., New York 16, N. Y., $4.*

This book covers the test instruments used in television, radio and the general electronics field in a nonmathematical manner which eliminates all unnecessary theory. The basic principles, operation, and construction of these instruments are covered, and their practical applications are discussed in such a way as to be helpful to the technician, the radio and tele-

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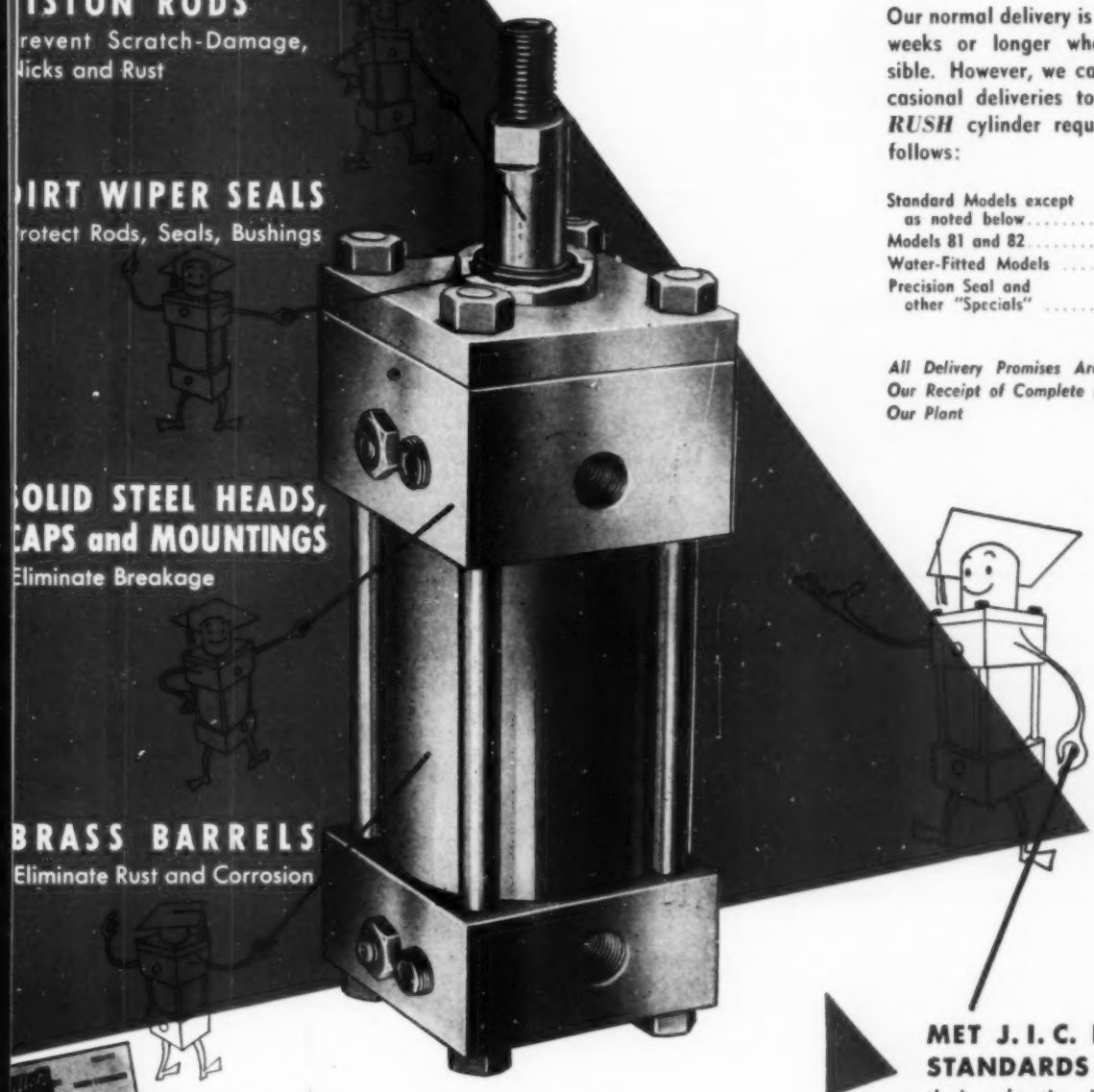

DELIVERY

Our normal delivery is now 8 to 10 weeks or longer whenever possible. However, we can make occasional deliveries to meet your ***RUSH*** cylinder requirements as follows:

Standard Models except as noted below	4-5 weeks
Models 81 and 82	6-7 weeks
Water-Fitted Models	7-8 weeks
Precision Seal and other "Specials"	8-9 weeks or longer

All Delivery Promises Are Dated From Our Receipt of Complete Information At Our Plant

WRITE FOR CYLINDER BULLETINS A-105 and H-104

Complete Miller cylinder line includes: air cylinders, 1½" to 20" bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

MET J. I. C. PNEUMATIC STANDARDS years before their adoption in 1950.

SPACE-SAVING SQUARE DESIGN originated by Miller in 1945.

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY • BUFFALO • ST. PAUL • GRAND RAPIDS • DETROIT • FLINT • FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE • KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE • DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • TORONTO, CANADA and OTHER AREAS

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MILLER MOTOR COMPANY

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AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
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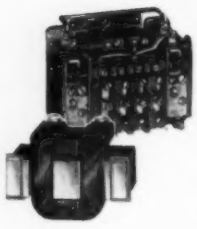
THERE IS AN R-B-M CONTROL To Fit Your Needs

A.C. MAGNETIC STARTERS
with Plasti-Clad Magnet Coil
•
Write for Bulletin 605



Full accessibility in a small package.

Contacts, coil and thermal element replacement with use of screwdriver only. Magnet coil—in molded phenolic case with riveted terminals—is completely embedded in a rock-hard resinous material, thus protecting against oil, dirt, moisture and normal mechanical damage.

HERMETICALLY SEALED RELAYS
•
Write for Bulletin ASR
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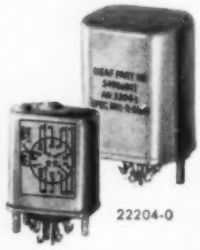


50% smaller — lighter.

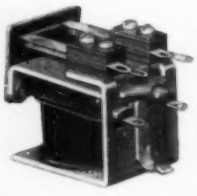
R-B-M 22204-0 meets AN 3304-1 specifications. R-B-M engineers have developed the 22300-0 currently used in government electronic, airborne and ground equipment—as the electrical and mechanical equivalent of the AN 3304-1, yet 50% smaller in size with ½ the weight.

INDUSTRIAL CONTACTORS
with Plasti-Clad Magnet Coil
•
Write for Bulletin 600
•

2-8 poles Non-Reversing.
2-5 poles Reversing.
25 Amp — 600 AC Max.

Contacts can be replaced without removing wiring. To change coil, remove magnet frame and coil assembly only. 10 and 15 amp. poles can be changed from normally open to normally closed by using screwdriver only.

GENERAL PURPOSE RELAYS
•
Write for Bulletin 570
•



Low cost. Small size. Dependable performance. Available in many contact arrangements.

Whatever your needs for inexpensive, dependable relays for commercial applications—investigate R-B-M General Purpose Relays.

Other R-B-M products include: motor overload protectors, motor starting relays and low voltage DC electrical devices.

Consult R-B-M On Your Control Problems—Write Department C-3

RBM
R-B-M DIVISION ESSEX WIRE CORP.
Logansport, Indiana
MANUAL AND MAGNETIC ELECTRIC CONTROLS
—FOR AUTOMOTIVE INDUSTRIAL COMMUNICATION AND ELECTRONIC USE

vision service man, the hobbiest, and the engineer. It is assumed that the reader has a fundamental knowledge of general radio and electronic theory.

The instruments covered are of major importance in radio and televivision servicing, audio-amplifier systems, radio and television research and development, industrial electronics maintenance and design, and to experimenters and radio amateurs.

Specifically, this book includes material on the following subjects: simple meters for current voltage, ohmmeters and volt-ohm-milliameters, vacuum-tube voltmeters, power measurements and power meters, impedance meters, can measurements, capacitor checkers, inductance checkers, special-purpose bridges and accessories, oscilloscopes and applications, R-F test oscillators and signal generators, audio test oscillators, frequency-measuring devices for radio frequencies, frequency-measuring devices for audio frequencies, audio-amplifier testing devices, R-F signal tracers, tube characteristics and tube testers.

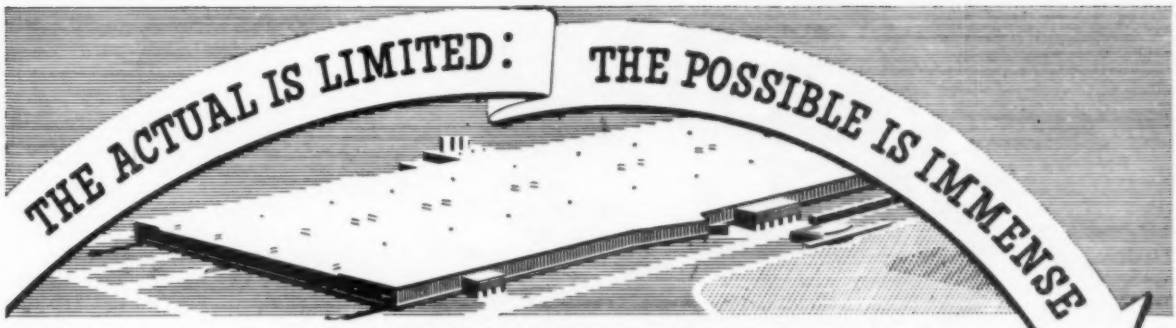
Electromagnetics

JOHN D. KRAUS, *Prof. of Electrical Engineering, The Ohio State University, 6 x 9 in., 604 pp. Published by the McGraw-Hill Book Co., 330 West 42 St., New York 36, N. Y., $9.*

This volume intended both as a textbook and as a reference work for practicing engineers, presents a thorough, well-balanced treatment of electromagnetic theory beginning with elementary principles of electric and magnetic fields and progressing through the more advanced theory and applications.

The first half of the book, suitable for an introductory course in field theory, covers static electric and magnetic fields, steady electric currents, and time changing electric and magnetic fields. The second half, qualified for a somewhat more advanced or intermediate course, is a continuation which treats space waves, guided waves, radiation, and boundary-value problems. The basic principles of electromagnetic theory are presented with approximately equal emphasis on those phases that find application to such diverse areas as electronics, radiation, magnetism, and propagation.

Important features of this text include the following: Graphical and analytical field mapping methods are discussed in detail and the very useful concept of curvilinear square volume or field cell is developed extensively.



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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WELDED STEEL DESIGN SIMPLIFIES PRODUCTION . . . CUTS COST ON MACHINE TOOLS

by **William B. Boice**
Boice-Crane Company, Toledo, Ohio

COSTLY machining operations like milling castings can be eliminated by designing for welded steel construction. On our jointer, for example, the top surface is now finish ground to close tolerance in one setup after welded assembly. Wherever machining is required, with steel construction precision tolerances are often held in one cut as compared to rough and finish cuts required on most castings.

Since steel is twice as rigid as gray iron, less material is needed to resist deflection under load. If made from castings, our jointer would weigh twice as much and still be subject to inaccuracies from deflection and warpage no longer experienced in the present welded steel construction.

With less material, less machining and fitting involved, shop costs are reduced. Furthermore, the modern appearance achieved with the welded design has greatly improved selling appeal.

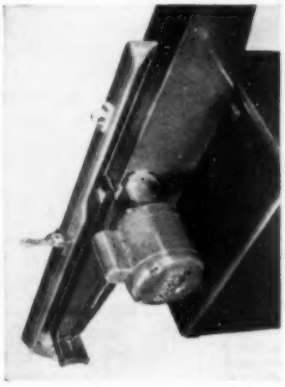

Fig. 3. Welded steel design *of 8" jointer is stronger, more rigid yet weighs half as much and costs less than cast construction. Courtesy, Boice-Crane Co.*

Fig. 4. Efficient girder-like structure *forms rugged frame for table. Top is welded to frame with intermittent welds and finish ground in one setting.*

WELDED DESIGN ALWAYS SAVES STEEL AND LOWERS COST

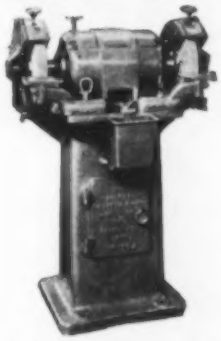

Fig. 1. Original construction *of pedestal grinder required costly milling and drilling using heavy machine tool equipment. Casting had to be filled and painted to obtain quality finish for sales appeal.*

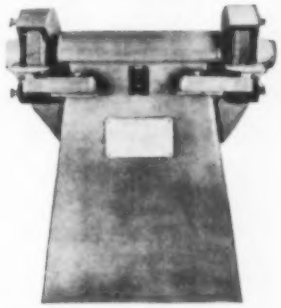

Fig. 2. Present welded steel design. *Quality of product and appearance improved to enhance sales appeal. Stability increased by lowering motor into pedestal base. Weight is cut 35% yet product is more rigid and costs 12% less to produce. Courtesy, The Bridgeport Safety Emery Wheel Co., Inc., Bridgeport, Conn.*

MORE PROOF

Machine Design Sheets available on request. Designers and Engineers write on your letterhead to Dept. 1302,

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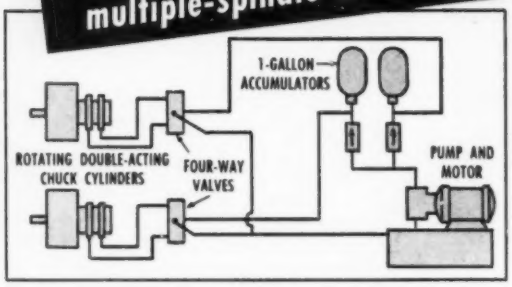
CLEVELAND 17, OHIO

THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

IMPACT for Chucking

GREER ACCUMULATORS deliver hydraulic SURGE on multiple-spindle machines



Functions Performed by **GREER ACCUMULATORS**

1. PRESSURE STORAGE CHAMBER to provide
   a. Main source of hydraulic power.
   b. Auxiliary power source.
   c. Emergency power source.
2. PRESSURE-VOLUME COMPENSATOR for
   a. Leakage compensation.
   b. Temperature compensation.
3. DISPENSER OF FLUIDS and Lubricants.
4. TRANSFER BARRIER for Fluids and Gases.
5. SHOCK ABSORBER to
   a. Absorb line shocks.
   b. Reduce pump pulsations.

Greer Accumulators deliver the hammer-like blow on the chuck jaws required to seize and release work on automatic multiple spindle machine tools. In the above simplified, schematic diagram the Greer Accumulator not only supplies power for actuating the chucks but also maintains line pressure for holding the work securely. A low-volume, high-pressure pump charges the accumulator during intervals between chucking. Without the accumulator, a pump to deliver the required surge of fluid would have to be so large and costly as to be economically impractical.

Let us help you to reduce the size, cost, and complexity of your equipment. No obligation. Write or phone.

GREER ACCUMULATORS

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A large number of worked examples are included, along with a great variety of tables of important formulas and useful relations, making reference to these relations easy and convenient. There is unusual clarity in the 663 illustrations and drawings. Very complete problem sets follow each chapter. A section on field mapping techniques contains a discussion of Mohr's new circle method. Finally, the appendix contains a complete table of units and useful tables and graphs of special functions.

High Speed Photography

GEORGE A. JONES, 6 x 9 *in.*, 311 *pages. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y.*, $6.50.

This book summarizes the fundamentals, current practice and scope of high speed photography in all its varied aspects. It is written for those who use high speed photography in scientific or industrial research or development work and for technicians interested in modern methods of machine performance analysis.

To avoid dull detail, only the outlines of equipment design, technique and applications have been given, except in certain cases not already adequately covered in the literature. For those requiring full details, extensive bibliographic references are given.

Chapter heads are as follows: Introduction and History; Production of Short Flashes; High Speed Cinematograph Camera Design; Photographic Materials; High Speed Still Photography; High Speed Cinematograph Cameras; Cinematographic Technique; Trace Recording Cameras; Picture-Making Recording Cameras; Scientific Applications of High Speed Photography; Industrial and Commercial Applications; Appendix A, High Speed Cameras; Appendix B, Gas-Discharge Flash Tubes; Appendix C, Formulae.

Meson Physics

ROBERT E. MARSHAK, *University of Rochester*, 378 *pp.* 6 x 9 *in. Published by McGraw-Hill Book Co., Inc.*, 330 *West 42 St., New York* 36, *N. Y.*, $7.50.

For the serious researcher in nuclear physics, this book presents, for the first time in one place, most of the information scientists have gathered on the meson.

To date there exists no genuine theory about the meson. But physicists have been able to prepare—what they

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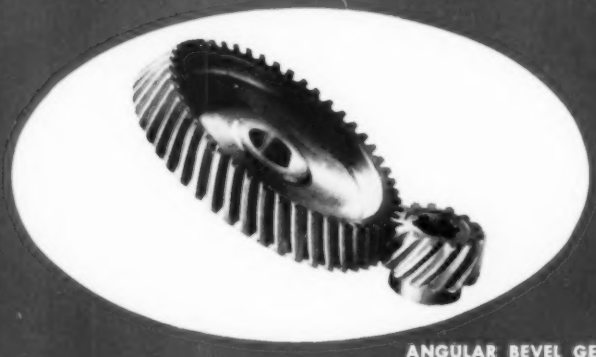
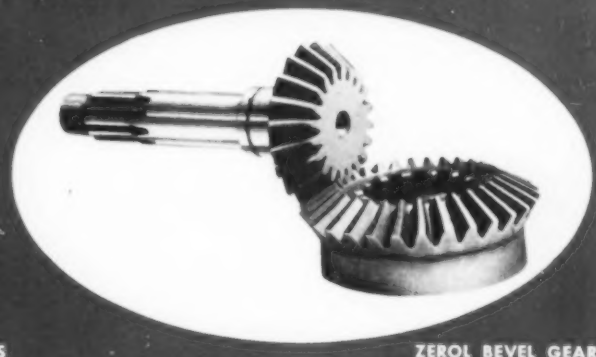
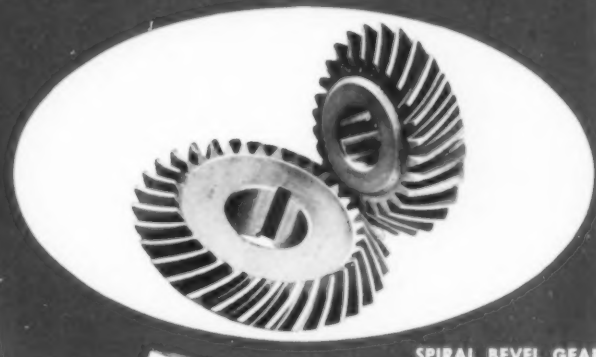
HYPOID BEVEL GEARS



ANGULAR BEVEL GEARS



ZEROL BEVEL GEARS



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The "SC" Bearing is a service-proved member of the Dodge 30,000 hour line. Modern styling. Rugged one-piece cast-iron housing. Long inner race. Radial and thrust load capacity. Fully self aligning. *WRITE* for complete information on the "SC" Bearing in the Dodge catalog.

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Precision built bearing for small shafts and moderate loads. Pillow blocks, flange bearings and hanger bearings available from distributors' stocks in shaft sizes ranging from 3/4" to 2-7/16".

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consider—plausible conjectures about these nuclear particles. Without endorsing any one, Professor Marshak offers several of these "theories" as a stimulus for future experiments.

The author restricts his text to real meson processes. By omitting consideration of nuclear phenomena that involve the particles as nuclear forces, he eliminates the most speculative theory.

Material is arranged in this manner: in the first four chapters there is an explanation of charged and neutral mesons' behaviour at non-relativistic nucleon energies. This covers the production and properties of π mesons. The next two chapters consider the abilities of different kinds to interact with the nuclei. Carefully covered are the capture and absorption of slow mesons and the properties of μ mesons.

Meson production at relativistic nucleon energies are then discussed and the author enters the field of speculation as to their source. Finally, the author reviews that which can be safely inferred on the basis of experimental results. He also indicates the theoretical quandary still facing physicists.

To understand Meson Physics, the reader must have a fundamental understanding of quantum mechanics.

Logic for Mathematicians

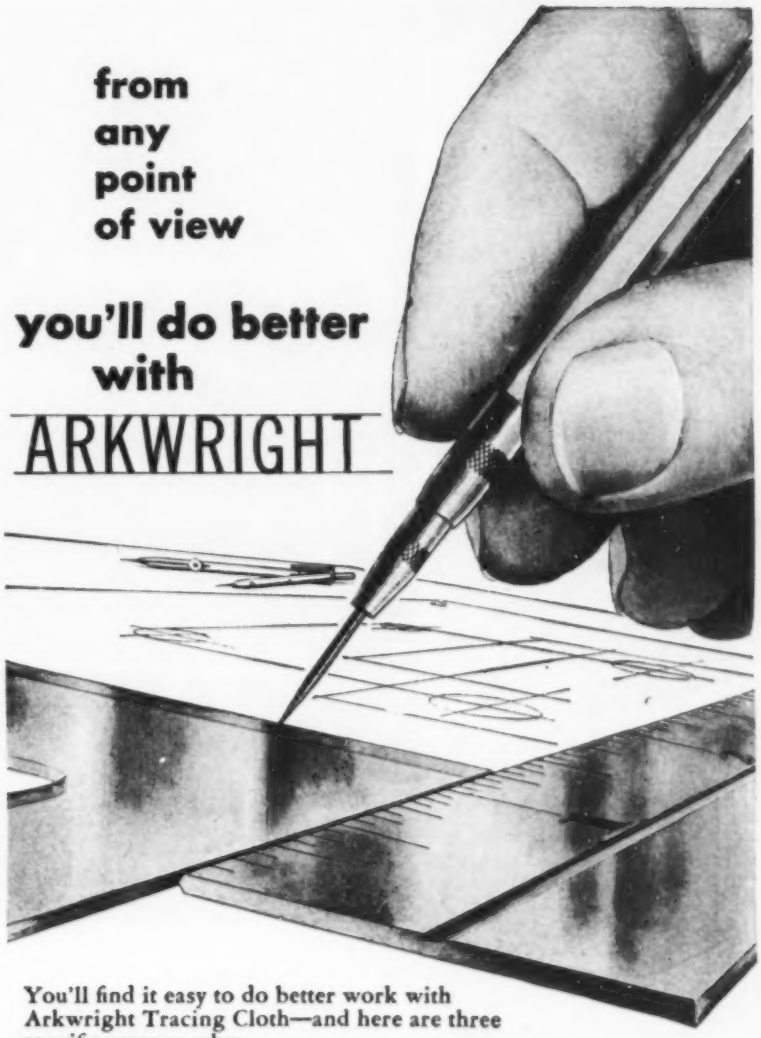
J. BARKLEY ROSSER, *Professor of Mathematics, Cornell University, 6 x 9 in., 530 pp. Published by McGraw-Hill Book Co., Inc., 330 West 42 St., New York 36, N. Y., $10.*

A text for the mathematician, this book presents the principles of logic used in daily mathematics. It is intended to make the tool of logic, necessary in mathematics, readily accessible to the working mathematician.

Logical theory, as applied to mathematics, is developed from first principles through the theory of cardinal and ordinal arithmetic, and includes careful consideration of existence, axiom of choice, etc.

No previous training in logic is necessary for an understanding of the text. However, in order to grasp the mathematical examples, the reader must have a knowledge extending through calculus.

Included are extended discussions of functions, presenting the two contradictory forms of function concept with an explanation of the method of integrating them; the notion of existence; and the axiom of choice (and Zorn's lemma). Much of the material presented in Whitehead and Russell's famous three-volume work, "Principia Mathematica," is here condensed.



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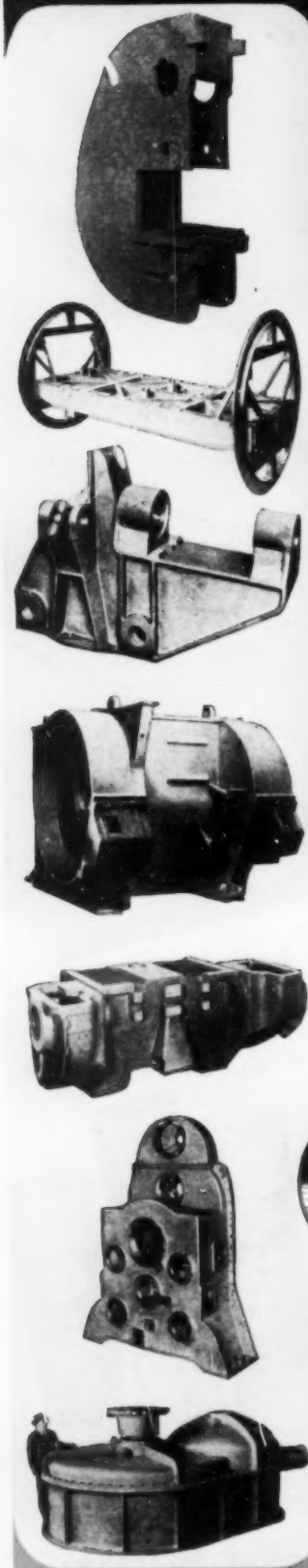
Steel-Weld FABRICATION



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In the illustration above you see a portion of the Mahon machine shop where welded steel parts and assemblies of various sizes and weights are machined to specification for many industries throughout the country. Facilities are available right in the Mahon plant to do the complete job from the drawing board to finished machining ready for assembly. If you have parts or assemblies that can be redesigned and produced to better advantage through Steel-Weld Fabrication, or, if you are faced with a production problem involving large heavy pieces in which pattern costs are a consideration, you can turn to Mahon with complete confidence. You will find in the Mahon organization a unique source with complete, modern fabricating, machining and handling equipment to cope with any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures you a smoother, finer appearing job embodying every advantage of Steel-Weld Fabrication. See Mahon's Insert in Sweet's Product Design File, or write for further information.

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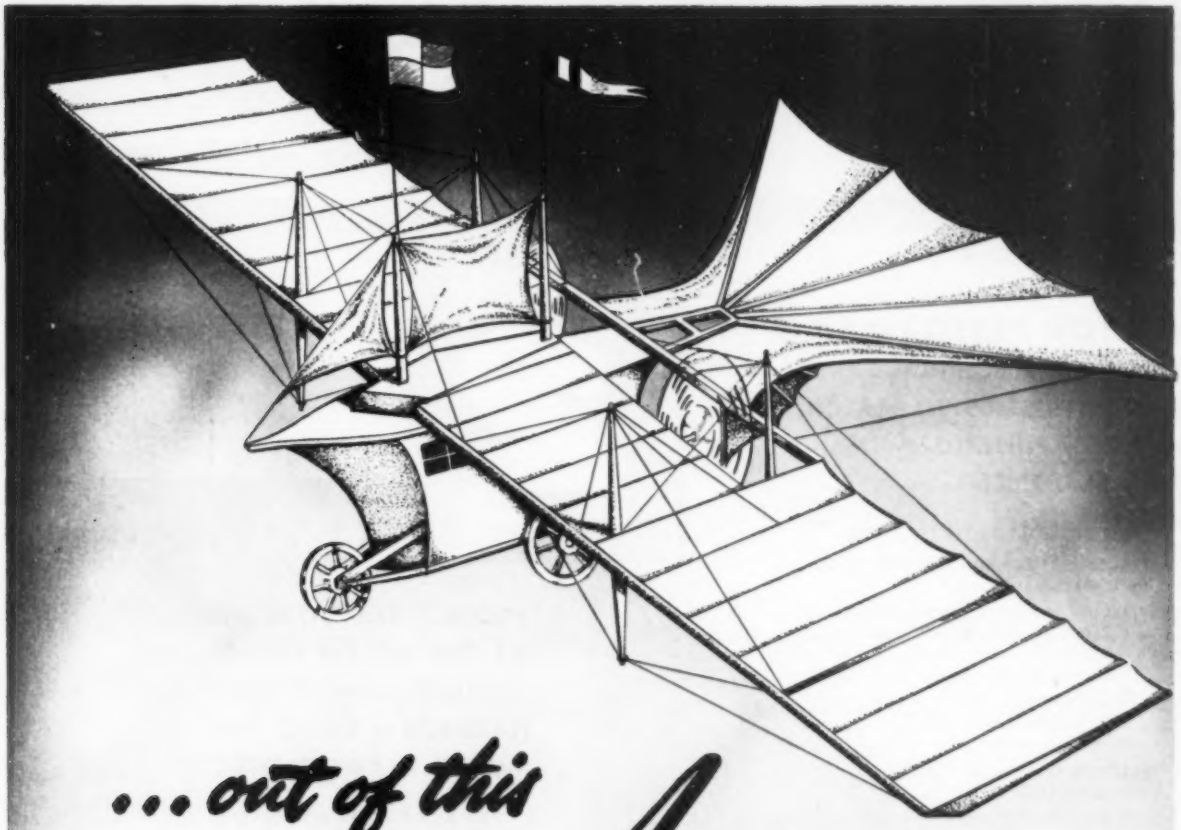
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON



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... an industry that created the need for suppliers with the manufacturing facilities and craftsmen to produce consistent quality precision parts and assemblies.

The Indiana Gear Works has been serving the aviation industry since 1933—accumulating twenty years of precision experience that enables I.G.W. to match design intelligence with creative production.

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- ☐ SINGLE PHASE OR POLYPHASE A.C. OR D.C.
- ☐ SELECTION OF RATING FROM WIDE RANGE —⅛ to 400 H.P.
- ☐ SELECTION OF PROPER LOADING FACTOR FOR SAFE TEMPERATURES AND EFFICIENT OPERATION:
  - ☐ Continuous general purpose rating.
  - ☐ Short time special rating.
  - ☐ With consideration to ambient temperatures for either of these.

SELECTION OF VARIOUS TORQUE CHARACTERISTICS FOR:

- ☐ Starting torque required which varies with class of equipment.
- ☐ Accelerating torque required which varies with inertia—friction—compression of the load.
- ☐ Maximum torque required which may vary with momentary overloads.

SELECTION OF TORQUE CHARACTERISTICS AND RATING FOR REVERSING ROTATION OF LOAD:

- ☐ Where motor comes to full stop before reversing.
- ☐ For instantaneous reversing (plugging) with reference to load inertia or other load factors.

SELECTION OF RATING FOR "START" AND "STOP" CYCLE FOR:

- ☐ Standard ratings for infrequent starts and stops.
- ☐ Special rating depending on frequency of starts and stops.

SPEED REGULATION AND CONTROL FOR:

- ☐ Select normal slip for good constant speed regulation.
- ☐ Select high slip, to absorb shock of impact loads.
- ☐ Select adjustable varying speed for uniformly constant load.
- ☐ For speed adjustment in fine steps, variable load, use adjustable voltage control.
- ☐ For speed adjustment in wide fixed steps, use multi-speed motors furnished for:
  - ☐ Constant H.P.
  - ☐ Constant torque
  - ☐ Variable torque

SELECT MOTOR WITH:

- ☐ Normal starting current for power circuits with good voltage regulation.
- ☐ Lowest starting current for power circuits where voltage fluctuates widely (R.E.A. lines).

PROTECT THE VITAL PARTS OF THE MOTOR FROM VARIOUS ATMOSPHERIC HAZARDS — SELECT THE MOTOR FRAME PROTECTION

☐ **DRIP PROOF—OPEN TYPE GENERAL PURPOSE FRAME**

For normal atmospheric conditions.

☐ **SPLASH PROOF—OPEN TYPE FRAMES**

Can be used out of doors without further protection or in plants where equipment must be washed down with a hose. For plants like dairies or other processing plants. Or for cooling towers, oil field pumping units, etc., out of doors.

☐ **DUST PROOF—TOTALLY ENCLOSED FAN COOLED FRAME**

The vital parts of the motor are sealed in. Used where the atmosphere is charged with abnormal amounts of dust, grit, oil fog, etc. This frame has high acceptance in high speed mass production metalworking plants or wherever a highly charged atmosphere would affect the life of the motor.

☐ **EXPLOSION PROOF—TOTALLY ENCLOSED FAN COOLED FRAME**

The frame is sealed in, in a manner which prevents a spark inside the frame from igniting combustible materials or gases outside the frame. The motors have an "Underwriters' Label" indicating the design has been approved by the Underwriters' Laboratories for certain specified classes of explosives.

☐ **TEXTILE—OPEN TYPE FRAME**

This motor is designed with wide open air passages, with smooth surfaces. It actually sheds lint, with which the air is highly charged in textile plants.

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help you select the right motor—

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For more than 50 years,

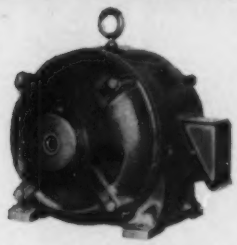
Century motors have been satisfying the requirements of equipment manufacturers — often with the most exacting specifications. This has produced a great teamwork between Century engineers and the customers' engineering department.

"Century OFFERS hundreds of mechanical forms for best adaptation to your equipment. ASK FOR IT— WE HAVE IT!"

STEP 3

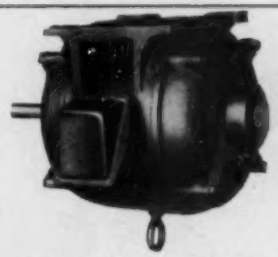
FOR IDEAL ADAPTATION OF THE MOTOR TO YOUR EQUIPMENT—

Here are a few samples of the many mechanical forms to select from

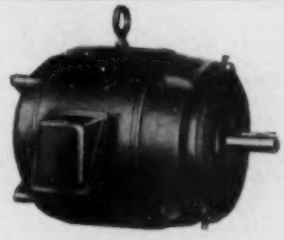


☐ 1. Horizontal—base mounted —solid type.

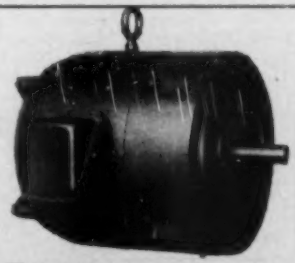
☐ 2. Horizontal—cushion mounted.



☐ 3. Horizontal—ceiling or side wall mounted.

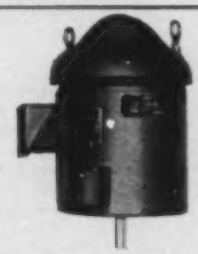


☐ 4. Horizontal, round frame—face type bracket. Equipment bolts to motor.

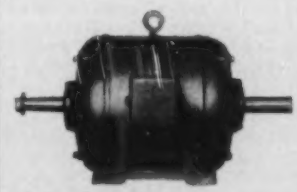


☐ 5. Horizontal, round frame—flange type bracket. Motor bolts to equipment.

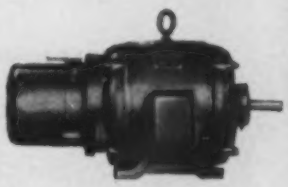
☐ 6. Vertical, round frame—face type bracket. Equipment bolts to motor.



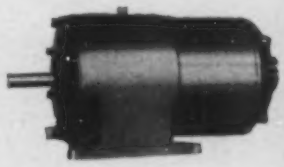
☐ 7. Vertical, round frame—flange type bracket. Motor bolts to equipment.



☐ 8. Double shaft extension—straight or tapered shafts.



☐ 9. Motor with magnetic brake.



☐ 10. Gear motor for extremely slow speeds—with parallel shaft.

☐ 11. Gear motor for extremely slow speeds—with right angle shaft.

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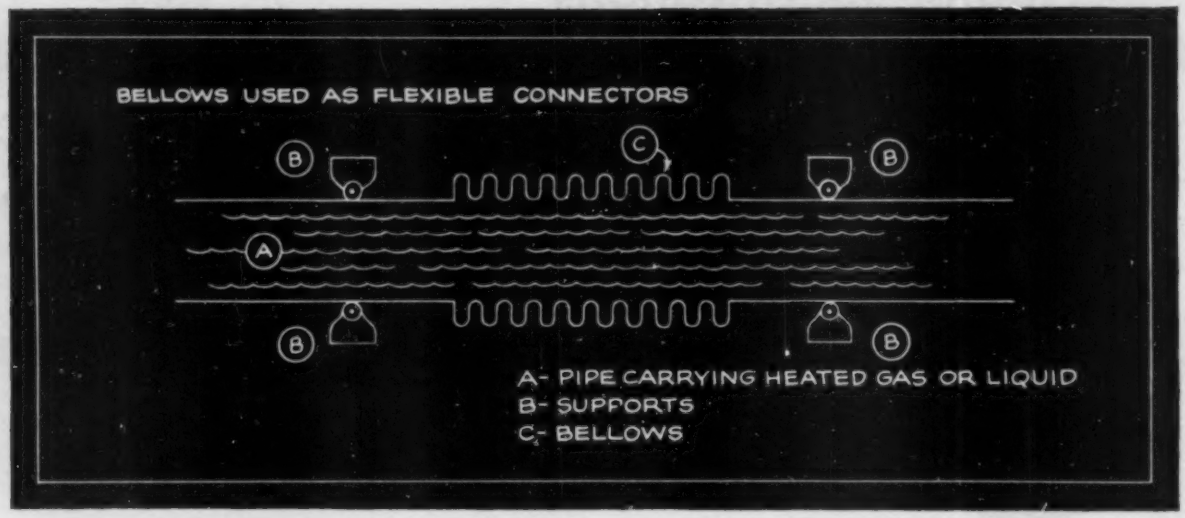
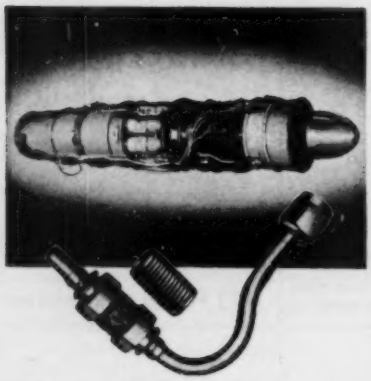
Bellows Digest

No. 5. Bellows used for Flexible Piping

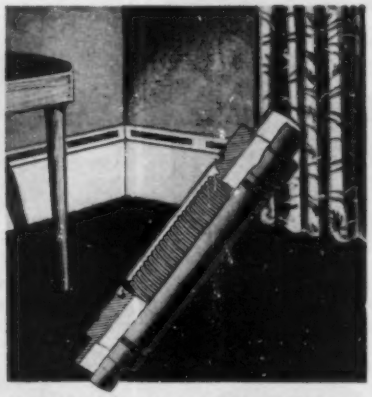


ONE OF MANY FLEXIBLE PIPING PROBLEMS solved by Clifford Hydron bellows is that of allowing for thermal expansion. Where heated gas or liquid would expand and buckle ordinary piping, the expansion or contraction of the flexible, leakproof bellows compensates for dimensional changes in the piping without imposing excessive strain on the supports. This also permits sidewise movement of supports with respect to each other. Another typical use of Clifford bellows as flexible joints is in hot-air de-icing ducts in airplane wings, where wing-flexing requires equivalent flexing of the ducts.



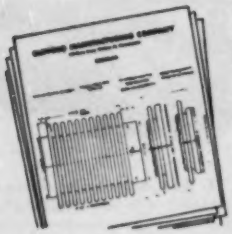
DESIGNED FOR JET ENGINES, Clifford's new flexible manifold assembly embodies a stainless steel bellows. Flexibility of the bellows withstands increasingly high temperatures, simplifies alignment problems, permits leakproof assembly of flare fittings and allows for thermal expansion.

FLEXIBLE JOINTS OF ANY DIAMETER from 7/8" to 26 3/8" are available with Clifford hydraulically formed stainless steel bellows. Made to desired specifications, they also serve many other applications where strength, flexibility, corrosion resistance and leakproof sealing are vital.



IN BASEBOARD RADIATION SYSTEMS, expansion joints incorporating Clifford bellows assure smoother operation, eliminating noise of pipes rubbing on timbers. Heating system makers also use Clifford bellows for steam traps, tank temperature control, mixing-valve thermostats, etc.

MAYBE YOU, TOO, CAN BENEFIT from the use of Clifford Hydron Bellows Assemblies. Besides their advantages as flexible joints in many types of applications, these flexible, leakproof, metallic bellows are also used to: (1) control and indicate temperature and pressure; (2) seal rotary shafts or packless valves against liquid or gas leakage; (3) transmit motion hydraulically to remote points; (4) provide shock mountings or vibration dampening; (5) permit motion in a vacuum.



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38.2.21

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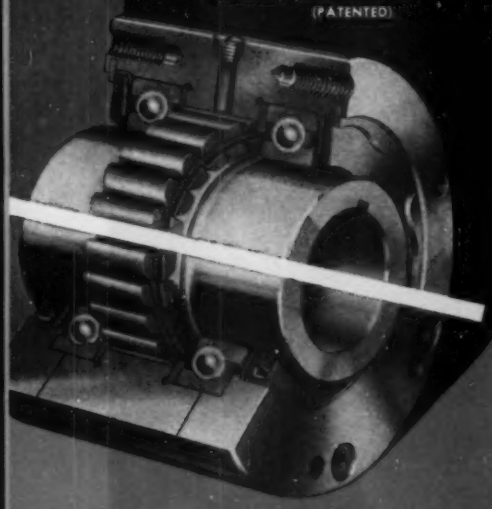
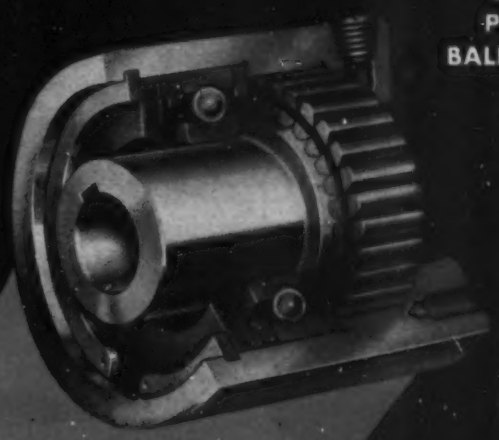


SPECIAL
PURPOSE
BALL BEARING
TYPE
(PATENTED)



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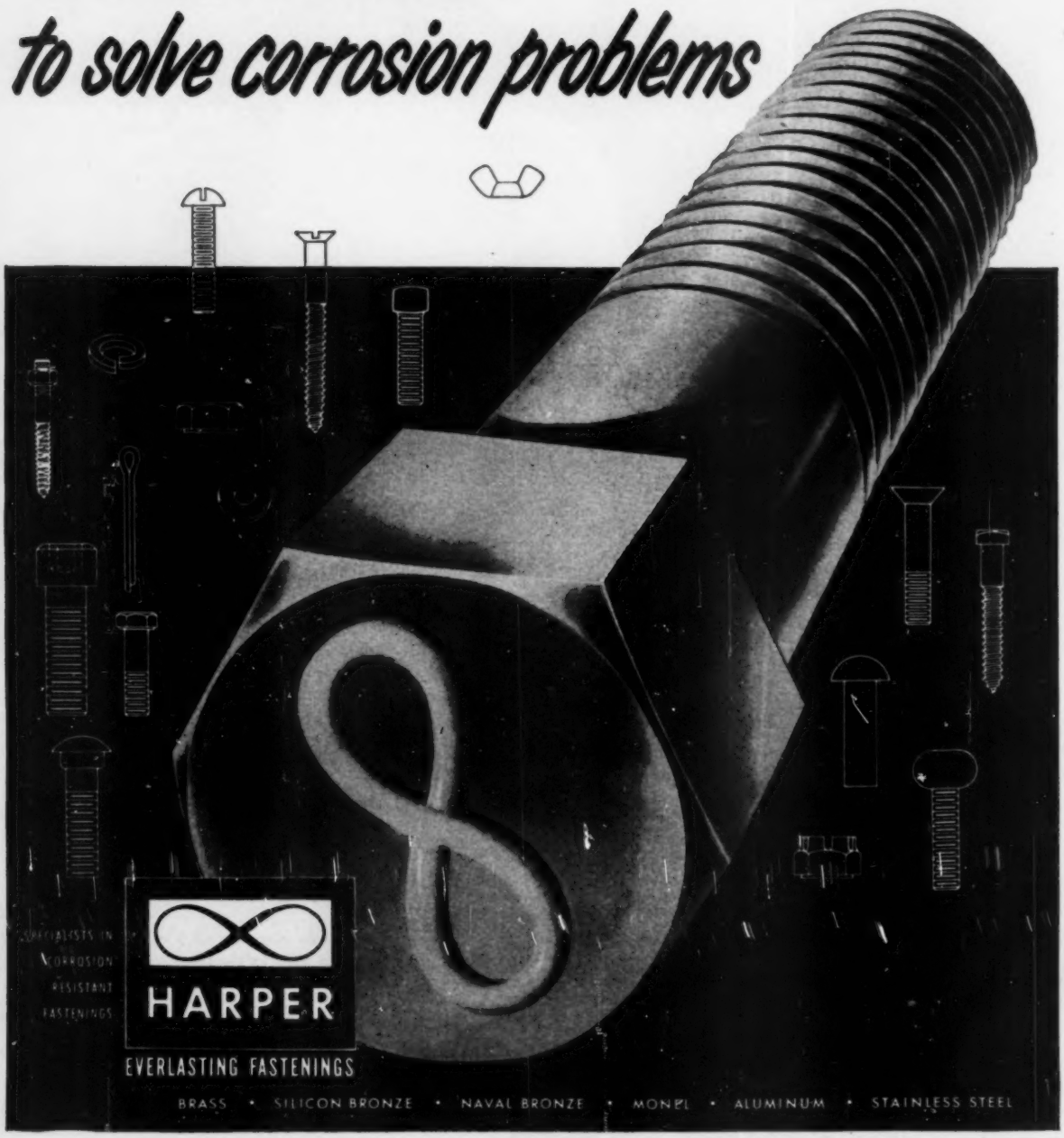
to solve corrosion problems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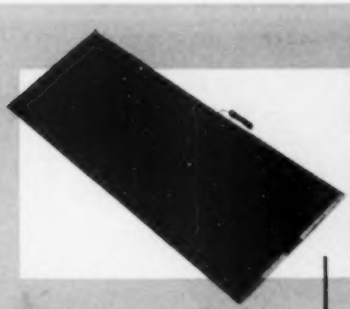
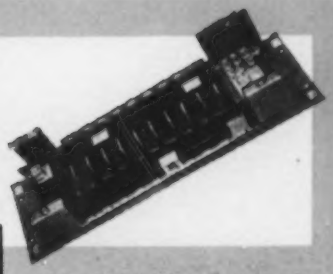
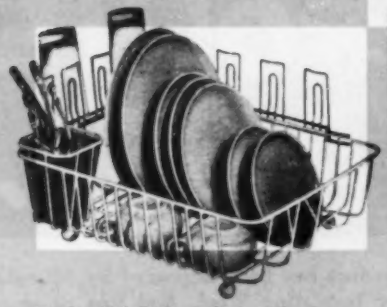


This carpet, molded of plastisols formulated from VINYLITE Resins, contains electrical components. Step on it, and a door opens. Easily-molded, plastisol simplified placement of internal contacts. It's resistant to cleaning solutions, moisture, weathering and abrasion. Surface showed virtually no wear after six months in a busy supermarket. The Stanley Works, New Britain, Conn.

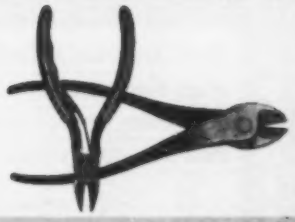


Putting insulation around the delicate copper conductors on this panel board was achieved with plastisols made from VINYLITE Dispersion Resins. They flowed safely into place after the board was assembled. Baking fused them into a firm material with excellent electrical properties. It keeps conductors 10 per cent cooler than air does. By Trumbull Electric Dept., General Electric Co., Plainville, Conn.

Sleevings for electrical insulation are glass fiber coated with plastisols made from VINYLITE Dispersion Resins. They stay flexible down to —65 deg. C., withstand continuous operation at 140 deg. C. They can be flexed, bent, twisted—without impairing dielectric value or rupturing. They are self-extinguishing, and resistant to moisture. By Suflex Corp., Woodside 77, N. Y.



A wire dish drainer, dip-coated with plastisols formulated from VINYLITE Dispersion Resins, protects dishes and glassware, hushes clatter. It has a combination of bright colors. Its plastisol coating clings to the wire covering, softens joints and corners, stays resilient, yet firm. It's easy to keep clean. By Artistic Wire Products Co., Inc., East Hampton, Conn.



Tools can be cushioned by dip-coating their handles or molding VINYLITE Dispersion Resin Plastisols to their jaws to help in holding wire. The plastisols hold fast to metal, withstand rough handling, abrasion, twisting and squeezing. Resilient, they give a better grip. Surfaces won't crack or peel. They resist oil, grease, chemicals, water. By Utica Drop Forge & Tool Corp., Utica, N. Y.

in this same way?

Data courtesy of Stanley Chemical Co., East Berlin, Conn.

Each product shown here had a problem in design or production—until VINYLITE Dispersion Resins were used.

Each required a particular combination of properties—which VINYLITE Dispersion Resins supplied.

Plastisols made from VINYLITE Dispersion Resins, being fluid, are easily formed, quickly applied, rapidly cured to their finished state. They serve equally well for molding or dip-coating. They can be given a range of brilliant colors—surfaces that are glossy or soft-textured. They stay resilient, pliable, and tough—resist water, weather, acid and alkali solutions, greases and oils. They have good electrical properties.

These features add up to long wear and a wide variety of uses. They're the same qualities that fit VINYLITE Resins and Plastics for scores of applications in defense and industry. For further information write Dept. PK-10.

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RESINS

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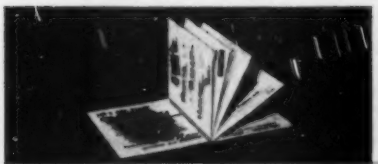
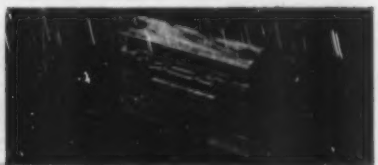


PROMOTION BOOKLETS with pages, covers and bindings made entirely of durable VINYLITE Plastic Rigid Sheets stay clean and shiny, resist moisture, oil, grease, withstand handling for long periods. Printing is in perfect register. By Hopp Press, New York, N. Y.

PROTECTIVE COVER for bubble glass on spirit level is made of BAKELITE C-11 plastic. Transparent and strong, it provides attractive appearance, high mechanical strength, less chance of breakage. By National Lock Co., Rockford, Ill., for Empire Level Mfg. Co., Milwaukee, Wis.



FORMING DIE for metals is made of densified wood—laminated veneers impregnated under pressure with BAKELITE Phenolic Resins. It offers high impact strength, light weight, ease of repair, economy. Easily machined. By Formica Co., Cincinnati, O.

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G	Gaskets
H	Heating Units, Hangars, House Trailers, Home Freezers
I	Ice Buckets, Incubators
J	Jugs (Picnic,) Jet Planes
K	
L	Lighting Fixtures, Life Jackets
M	Metal Buildings, Marine Vessels, Milk Trucks
N	
O	Outerwear, Office Machines
P	Pre-Fabricated Buildings, Pillows, Packaging
Q	
R	Railroad Cars, Refrigerators
S	Steamships, Sea Food Boxes
T	Truck Trailers (Refrigerated), Table Pads
U	Upholstery Filler
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W	Warm Air Furnaces, Water Heaters, Winter Clothing
X	
Y	
Z	

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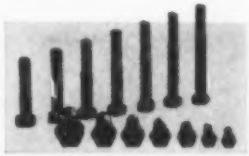

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PLANT 1
Detroit, Mich.

PLANT 2
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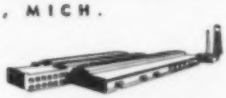
PLANT 3
Hillsdale, Mich.



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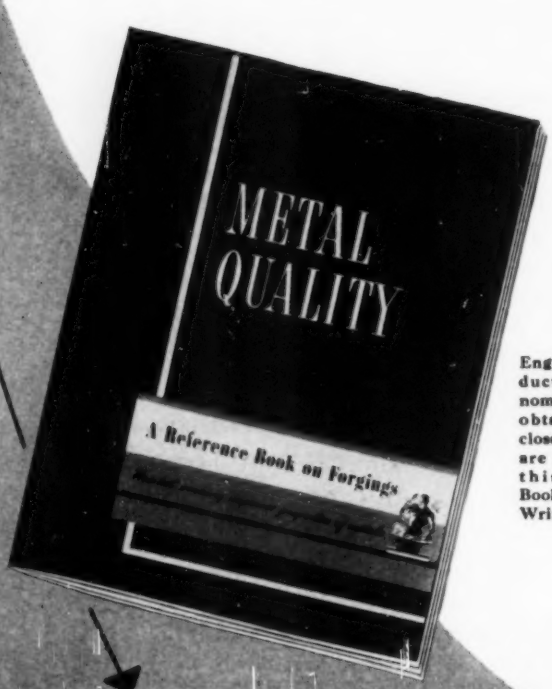

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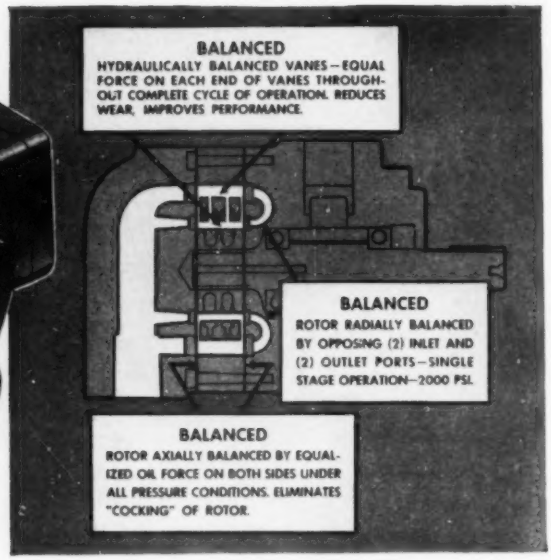
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SIMPLICITY! Dual-purpose, bi-directional operation makes Denison Pump/Motors your most dependable answer to the widest range of *pump and motor* needs in the 2000 psi range. *Write today for bulletin P-5.*

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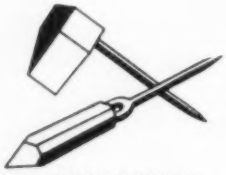

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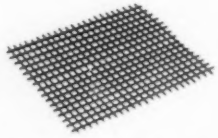

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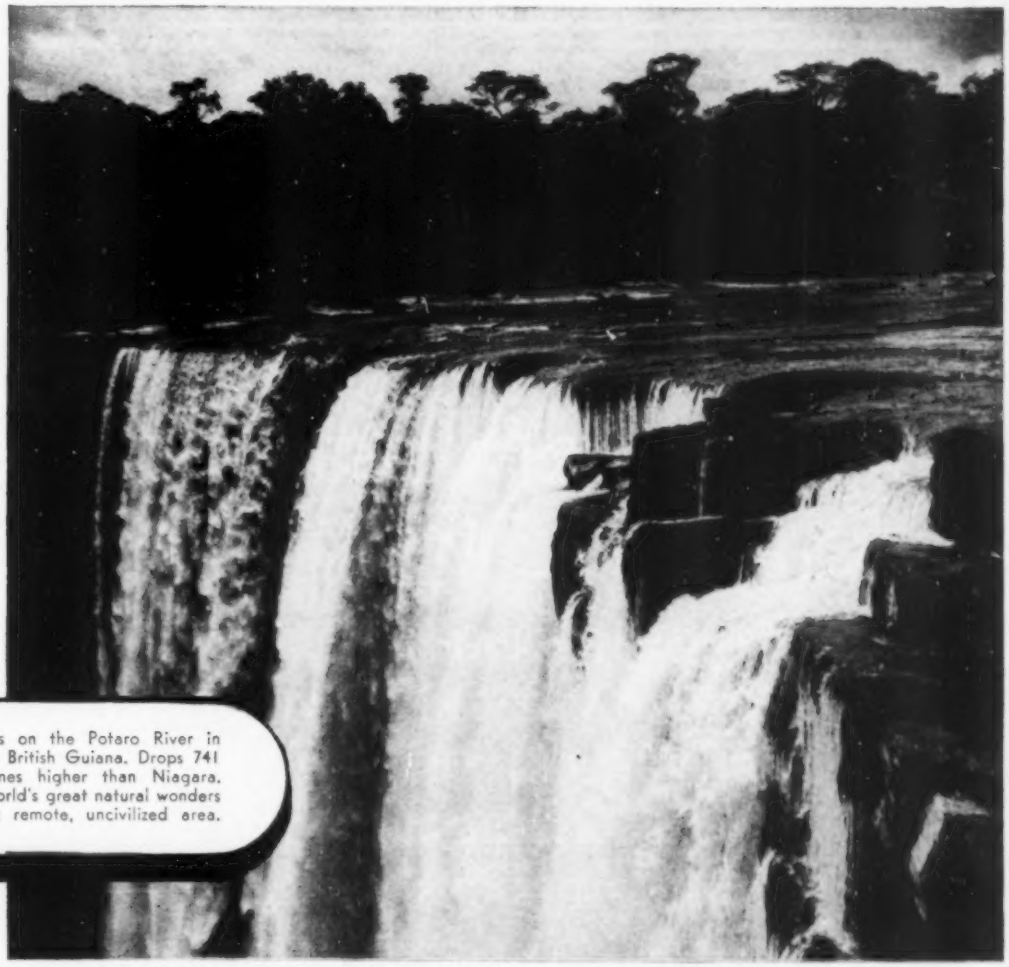

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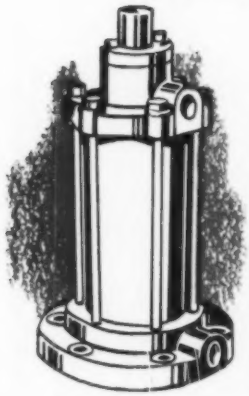

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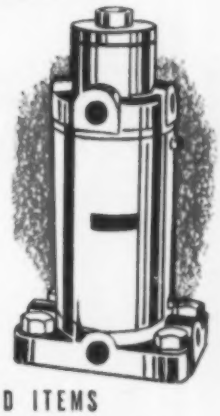

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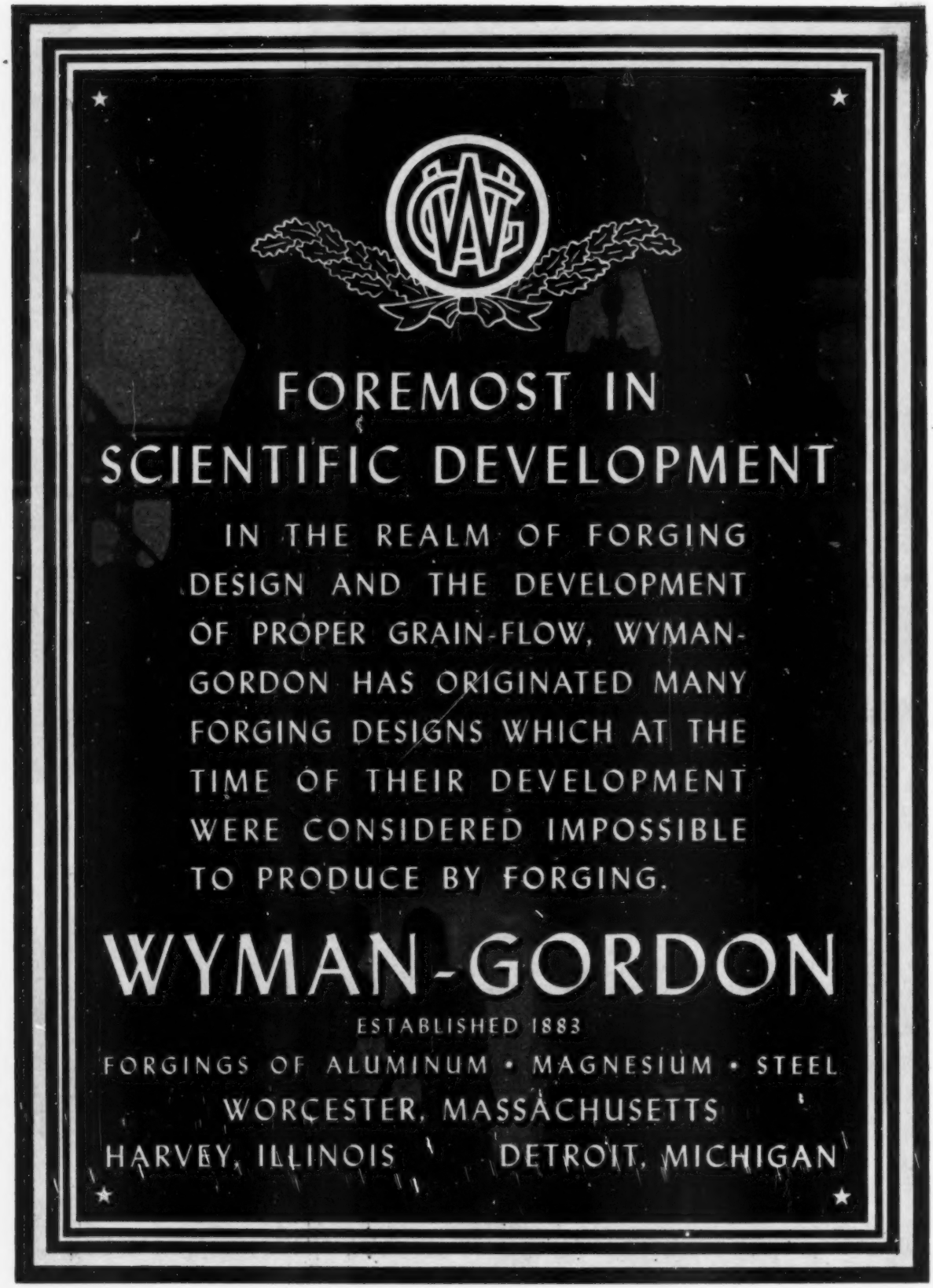
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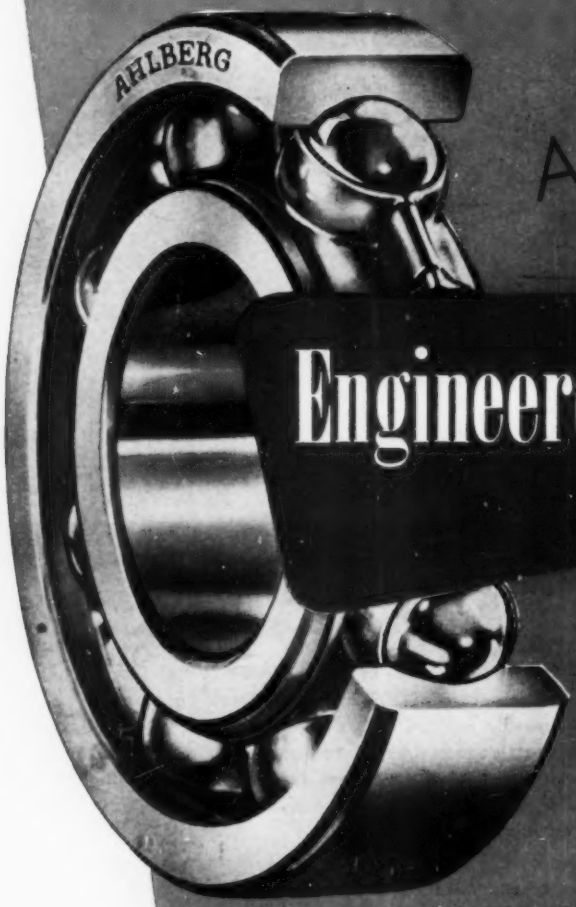

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You'll never see and never hear that "golden" silent Celoron timing gear running in your Studebaker, but it gives your car good performance and reliable ignition.

Let's go back to when cars were carriages and all gears were metal, regardless of their function, or the amount of noise they made.

The plastics industry was fresh out of the mold. Vulcanized Fibre (like we've made since 1895) was a relatively new product. The thought of using a laminated thermosetting material sent chills through the hardened arteries of job-conscious engineers.

Up front in every car were two metal gears, working off the camshaft, to regulate the ignition timing action of the car. They whined and rattled. They wore, and car owners swore at the high cost of replacement and at that infernal gear clatter.

Along came some enterprising gents with an idea, and a new C-D-F material: CELORON, a golden, laminated material made from selected canvas duck and a special phenolic resin. They boldly suggested that a gear cut from Celoron sheet stock could replace one of the metal timing gears . . . and that it would eliminate this "up front" engine noise.

By gosh, they were right! Celoron gears worked. Noise was eliminated; gears ran better and lasted longer. Lubrication was no problem. Car builders with imagination (Studebaker was one of the first), hopped on the Celoron bandwagon.

Today Celoron timing gears are used in every Studebaker and are the finest, strongest gears available. Gear timing has proven superior to other methods tested by the company.

A Celoron gear is individually molded! The rim is made of layer upon layer of woven cotton fabric that has been resin-impregnated, then laminated. These layers are laid edgewise to give each tooth the same high strength. Studebaker did not copy other gear designs . . . they use an exclusive spoke construction which reduces the noise level below that of any other design, and also provides increased flexibility for excess torsional stresses. Each gear and its metal mating gear is precision cut and minutely inspected. The owner of any Studebaker can be certain that every effort has been made to insure long life and smooth running of these vital Celoron gears.

Studebaker builds the best because they have engineering imagination. They are not limited to old materials, old ways. The Celoron timing gear, made from a golden, strong, silent material, in your new Studebaker is proof of this.

THE NAME TO REMEMBER CDF ...FOR CELORON TIMING GEARS

Continental-Diamond Fibre Company

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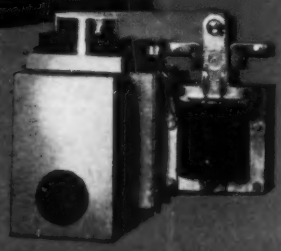
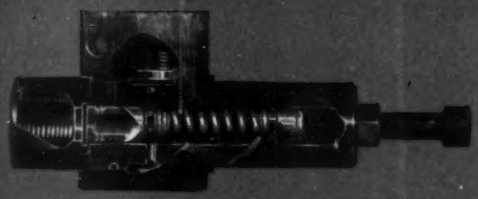
High Pressure
SOLENOID VALVES . . .



have working pressures range as high as 3000 psi. Specifically designed for remote push button control of hydraulic systems, as well as for the handling of any non-corrosive fluids. Poppet construction eliminates leakage. Impregnated coils are oil and moisture resistant. Unit can be mounted in any position. Available in 110-220 A.C.

ADJUSTABLE
FLOW REGULATORS



for cylinder speed control over a 50% range are built for pressures to 3000 psi. Model 320 shown meets requirements for cylinder speed adjustment yet maintains constant speed regardless of work or pressure fluctuations. There are types for Machine Tools—Earth Moving, Material Handling and Farm Equipment—Packaging Machinery—Steel and Paper Mills—Refineries—Printing Presses.

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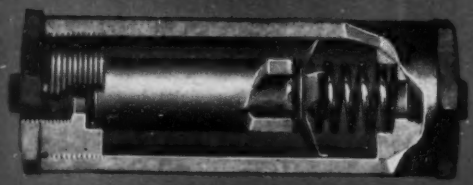

are made in pressures to 3000 psi for air, oil, water and other fluids. Compact—simple in design—have built-in durability—easy to clean. Micronic element filters to 40 Microns providing full protection for pumps, valves and cylinders. The elements, low in cost, are easily replaced. Make possible maximum flow with minimum pressure drop.

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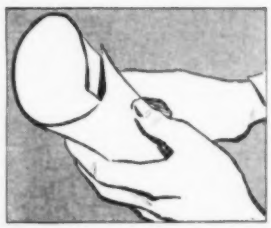
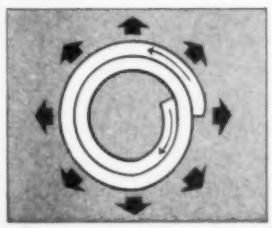
SPIRAL SPRING COILS MAKE SPIROL PIN

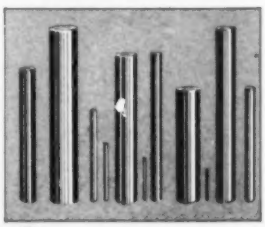


1 Roll a piece of paper spirally into a double coil. This is the way SPIROL PINS are rolled of steel or other flexible materials.

2 Compress roll and insert into circle of thumb and forefinger. Note "live action" as it expands to lock itself in circle. This is the SPIROL PIN principle.



3 When compressed by insertion, SPIROL PIN immediately develops *evenly distributed* radial tension, holding it firmly in place.



4 Standard SPIROL PINS from 1/32" to 1/2" diameters, and 1/8" to 4" lengths. Non-standard diameters, lengths & materials available on order.

The all-around tension provided by spiral coils gives SPIROL PIN unique fastening properties. Radial spring action locks SPIROL PIN in place . . . eliminates close tolerances . . . allows easy removal and reuse of pin. The design provides an infinite range of controlled variations in shock and shear resistance, insertion pressure, and flexibility.

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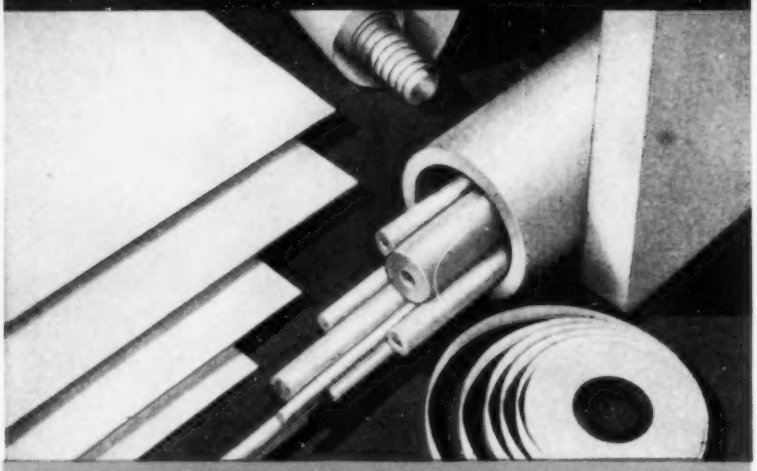

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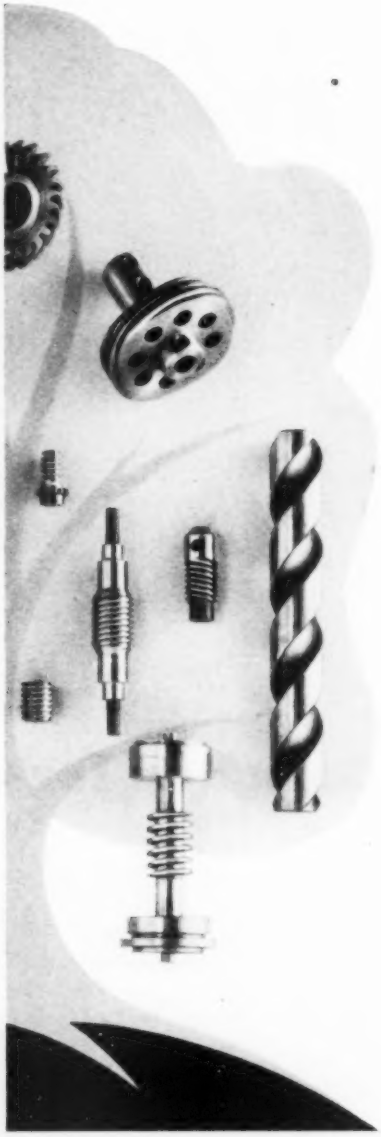

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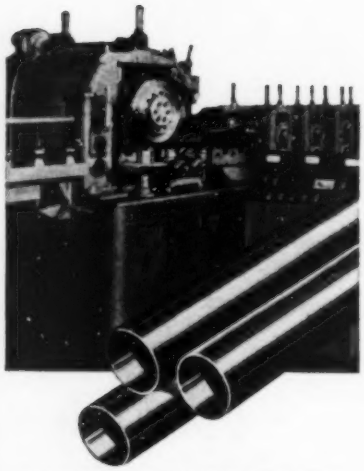

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* SAN FRANCISCO—424 Bryant Street, San Francisco 7, Calif.
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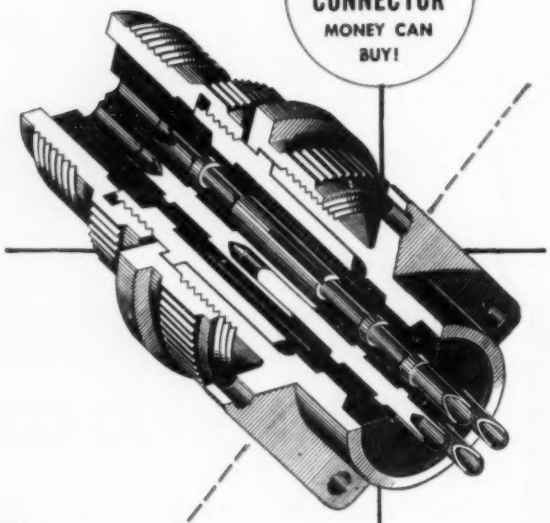
The Finest
ELECTRICAL CONNECTOR MONEY CAN BUY!



SCINFLEX ASSURES
LOW MAINTENANCE BECAUSE
IT PERMITS SIMPLICITY

When operating conditions demand an electrical connector that will stand up under the most rugged requirements, always choose Bendix Scinflex Electrical Connectors. The insert material, an exclusive Bendix development, is one of our contributions to the electrical connector industry. The dielectric strength remains well above requirements within the temperature range of −67°F to +275°F. It makes possible a design increasing resistance to flashover and creepage. It withstands maximum conditions of current and voltage without breakdown. But that is only part of the story. It's also the reason why they are vibration-proof and moisture-proof. So, naturally, it pays to specify Bendix Scinflex Connectors and get this extra protection. Our sales department will be glad to furnish complete information on request.

• Moisture-Proof • Radio Quiet • Single Piece Inserts • Vibration-Proof • Light Weight • High Insulation Resistance • High Resistance to Fuels and Oils • Fungus Resistant • Easy Assembly and Disassembly • Fewer Parts than any other Connector • No additional solder required.

BENDIX SCINFLEX
ELECTRICAL CONNECTORS

Bendix

SCINTILLA MAGNETO DIVISION of Bendix AVIATION CORPORATION
SIDNEY, NEW YORK

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, N. Y.
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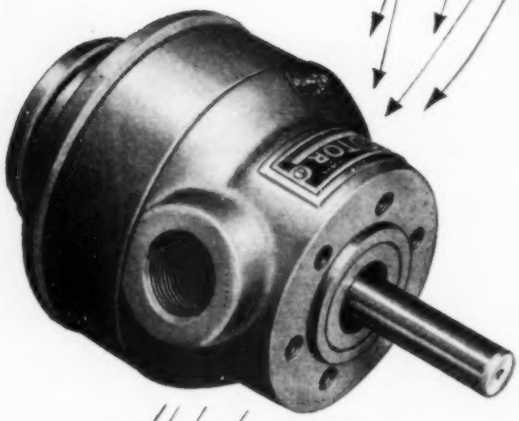
the "label" tells you it's unique



no other hydraulic pumps are like

See the Gerotor name-plate on a hydraulic pump and you know what's inside . . . the renowned Gerotor mechanism. Both elements revolve in the same direction at low relative speed . . . minimizing friction, wear and slippage . . . assuring longer life, smoother flow, higher efficiency at lower operating cost. Eleven pump sizes, some engineered for pressures up to 1200 p.s.i. continuous, 1500 p.s.i. intermittent. Specify Gerotor!

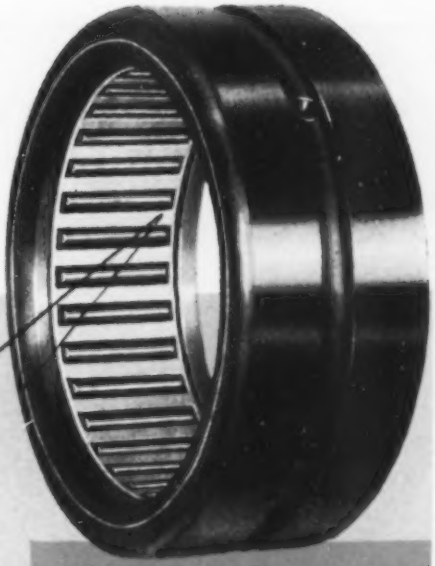
Gerotor May Corp., Box 86, Baltimore 3, Md.

GEROTOR
HYDRAULIC PUMPS

This ORANGE *Cage Design*

assures permanent alignment of rollers

--prevents roller skewing!



TRUE RUNNING IN ANY POSITION

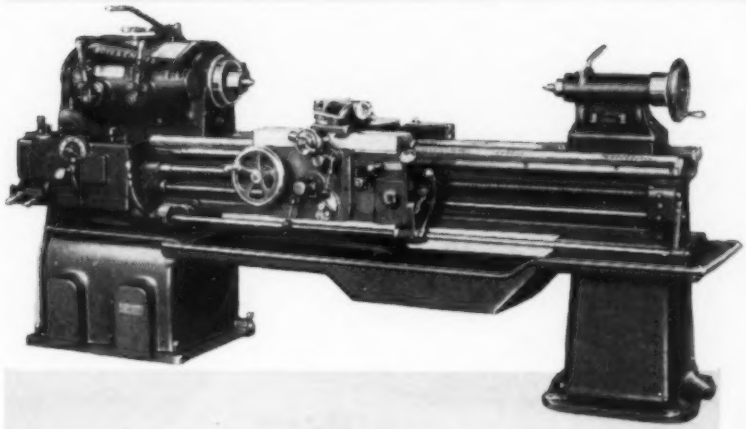
on

- --conventional applications
- --vertical installations
- --overhung mountings
- --relatively high speed applications
- --and are less affected by misaligned mountings and uneven loading.

ORANGE

Cage Type

NEEDLE BEARINGS



Meeting critical needs in Gear Box and Apron of 14"-16" BOYE & EMMES ENGINE LATHES

Orange Cage Type Needle Bearings are used as follows: One on the gear box center shaft—three in train gears from spindle to gear box—one in the apron. Boye & Emmes engineers selected these bearings "because of their high radial capacity, small outside diameter and comparatively large inside diameter." They report trouble-free performance from all machines in the field.

Orange Cage Type Needle Bearings provide the big advantage of high load capacity in small space—plus the additional feature of permanent roller alignment. This permits you to design needle bearings into many applications heretofore unsuited to other needle bearings.

In the Orange cage design, square end rollers are retained in pockets of a free-floating, land-riding cage of anti-friction, non-ferrous metal. The cage merely guides—does not wear on rollers. All rollers and races are "Pentrate" finished to reduce corrosion and friction.

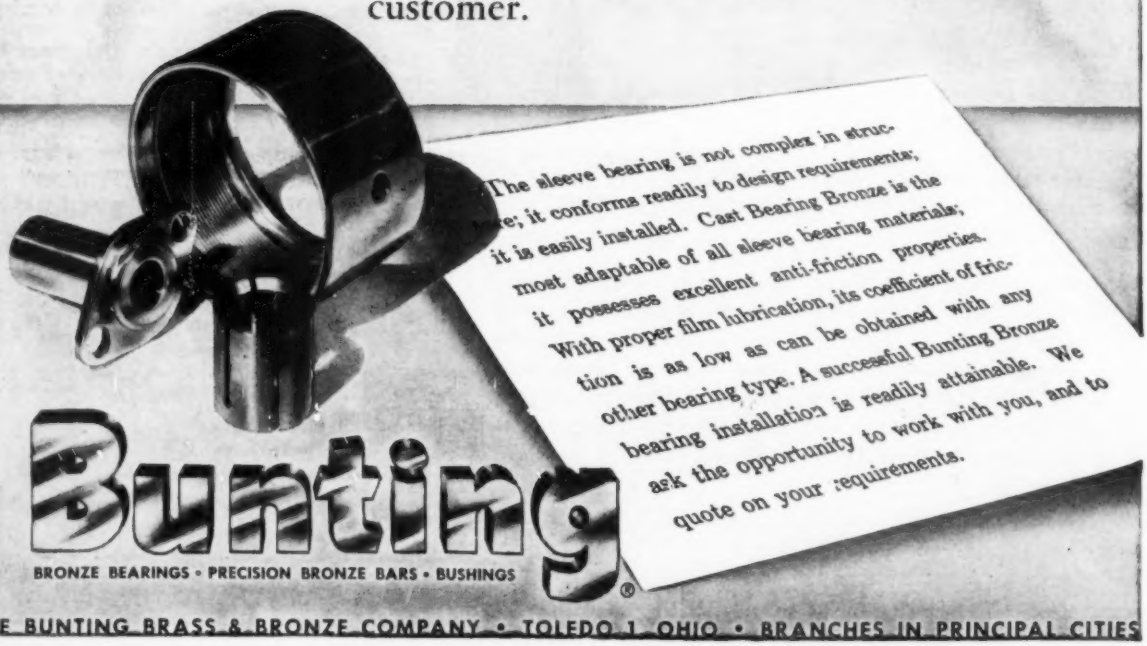
This combination of operating characteristics in Orange Cage Type Needle Bearings provides every installation with quiet, precision running and long, trouble-free service.

• Write for Engineering Data Book showing construction, sizes, capacities, etc.

ORANGE ROLLER BEARING CO., INC., 551 Main Street, Orange, N. J.

"customer conscious..."

You are treated like a customer when you deal with The Bunting Brass & Bronze Company. It is a tradition in the Bunting organization to consider the good will of the customer as the most important factor in the transaction. Bunting customers find that Bunting resourcefulness no less than Bunting products, is made available when needed . . . Ask any Bunting customer.


The sleeve bearing is not complex in struc-
it is easily installed. Cast Bearing Bronze is the
most adaptable of all sleeve bearing materials;
it possesses excellent anti-friction properties.
With proper film lubrication, its coefficient of fric-
tion is as low as can be obtained with any
other bearing type. A successful Bunting Bronze
bearing installation is readily attainable. We
ask the opportunity to work with you, and to
quote on your requirements.

Bunting®

BRONZE BEARINGS • PRECISION BRONZE BARS • BUSHINGS

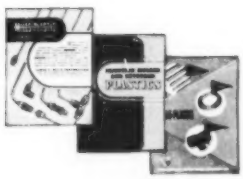
THE BUNTING BRASS & BRONZE COMPANY • TOLEDO 1, OHIO • BRANCHES IN PRINCIPAL CITIES

Flashlight Housing molded for
BURGESS BATTERY CO.
Freeport, Illinois

Skillful Molding

solves a flashlight's housing problem

Economical production has a special meaning for us that always results in better plastic products for you. Low priced—high volume items like this Burgess pocket flashlight illustrate how we put economy and quality to work together. Naturally costs had to be kept down while keeping quality "up" in producing this flashlight housing. Although it is a small and outwardly simple case, actually there was a definite and unique problem solved by making full use of a surprisingly compact space. Through careful engineering and advance planning we have developed our own method of cutting costs without ever cutting quality. This production skill that saves you money while giving you a better job is the core of our service to you. Let us show you how we can combine economical production and quality craftsmanship for your product. Tell us today when you want to see us.

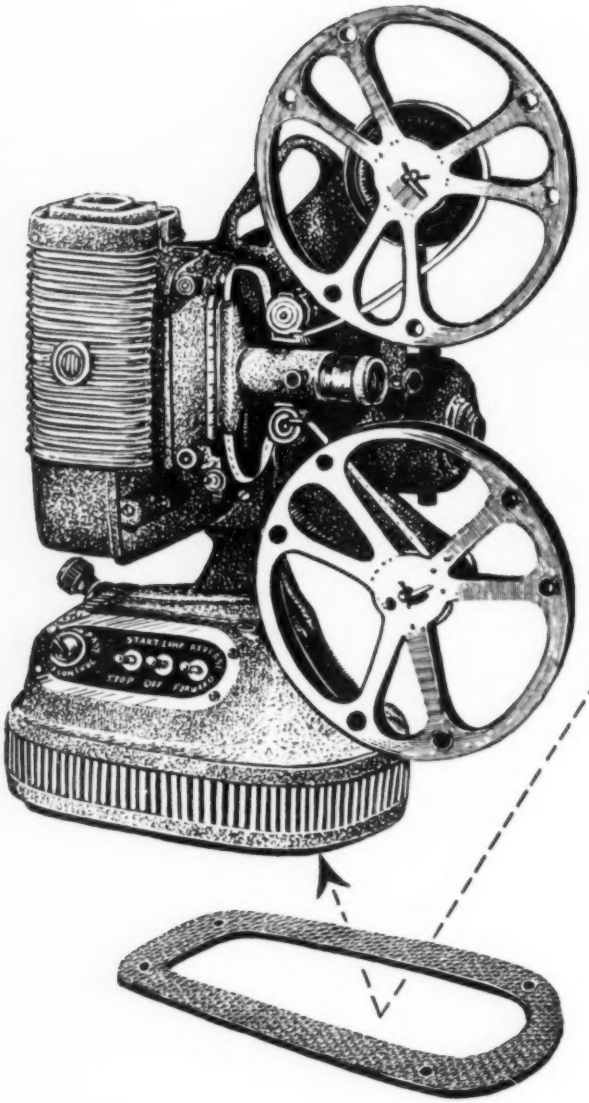


Write on your letterhead for new Injection Molded and Extruded Plastics Catalog. Or, for detailed information about [illegible]*, piping, tubing and fittings, write for circulars containing data and illustrations.*
**Trademark Registered*

ELMER E. MILLS CORPORATION

INJECTION MOLDERS and EXTRUDERS of: Tenite, Lumarith, Plastacele, Fibestos, Lucite, Nylon, Plexiglas, Polystyrene, Styron, Loalin, Vinylite, Geon, Plexene, Polyethylene, Cerex, Forticel, [illegible]*, Saran, and other Thermoplastic Materials.

2930 NORTH ASHLAND AVENUE • CHICAGO 13, ILLINOIS



extra performance

at less cost with

SPONGEX CELLULAR RUBBER

DeJUR 8 mm. movie projector uses SPONGEX base to dampen vibration, prevent crawling and protect surfaces.

A simple die-cut shape from Spongex sheet stock, gives DeJUR owners a projector that has less motor vibration, sits more firmly and will not crawl on smooth surfaces.

This inexpensive extra wins thousands of friends for DeJUR. Perhaps your product could use Spongex to increase its efficiency, reduce costs or give better service.

There are literally hundreds of uses for Spongex sheet stock. You can cut your own applications from Spongex sheets or rolls—or we'll die-cut to specification.

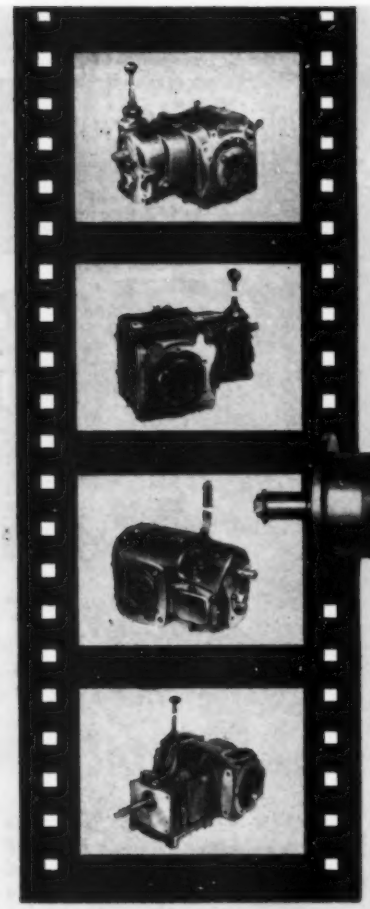
If you need cellular rubber with special qualities—such as flame resistance, oil resistance—performance under high or low temperature—there's a Spongex sheet stock compounded for the job.

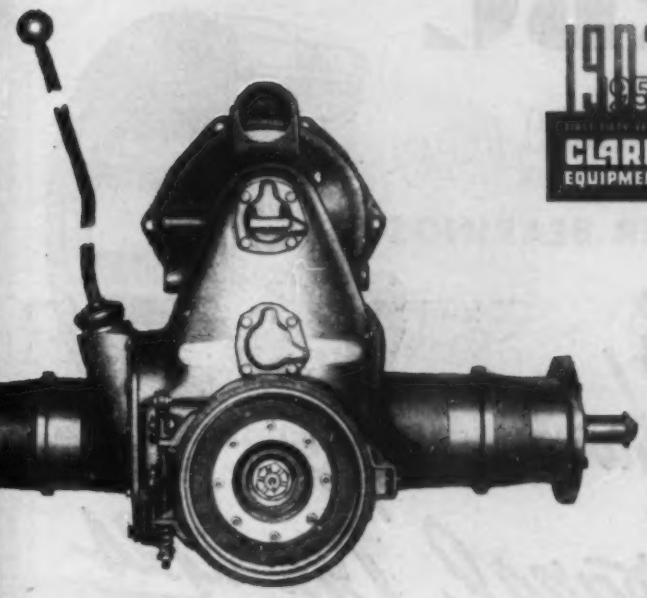
SPONGEX® Cellular Rubber

used for cushioning, insulating, shock absorption, sound and vibration damping, gasketing, sealing, weatherstripping and dust proofing.

THE SPONGE RUBBER PRODUCTS COMPANY

602 Derby Place, Shelton, Conn.





1903 1953 CLARK EQUIPMENT

RUGGED *dependability*

The folks who design and build today's heavy-duty automotive, farm and road building equipment have developed some mighty high standards when it comes to rugged dependability, efficiency and performance. No doubt that's why so many of them specify CLARK Drive Units for that all-important job of power transmission . . . and have done so for years. Ask any of them. They'll tell you that "it's good business to do business with CLARK."

CLARK EQUIPMENT COMPANY
BUCHANAN, MICHIGAN

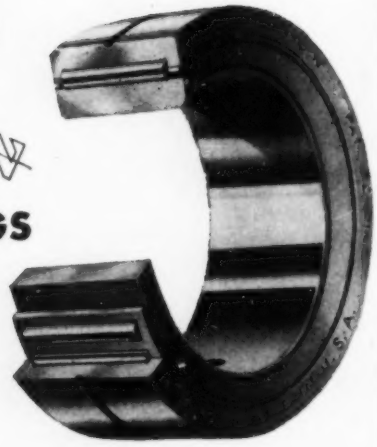
Other Plants: **BATTLE CREEK** *and* **JACKSON, MICHIGAN**

PRODUCTS OF CLARK — TRANSMISSIONS • AXLES • AXLE HOUSINGS • TRACTOR DRIVE UNITS • FORK TRUCKS AND TRACTORS • POWERED HAND TRUCKS • GEARS AND FORGINGS • ELECTRIC STEEL CASTINGS

RBC

PITCHLIGN

ROLLER BEARINGS

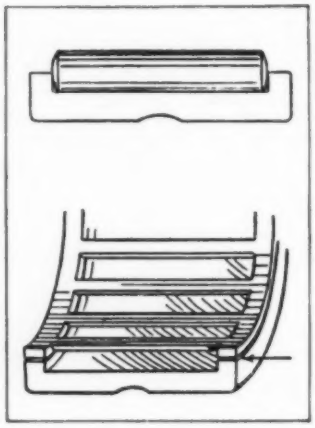


...have Integral Flanges

Rollers are located axially by direct contact with the flanges which present a continuous surface to the ends of the rollers. As a result, it is impossible to have end thrust against the cage.

Integral flanges support the free-floating cage which does not ride the rollers, but acts only to align them at their pitch circle. Flanges serve also to retain lubricant.

PITCHLIGN is interchangeable with precision needle bearings. Get all the facts!



PITCHLIGN
TRADE MARK
ROLLER BEARINGS

GET THE FACTS!

Write Today

Ask for Bulletin SF-165

RBC

ROLLER BEARING COMPANY OF AMERICA • TRENTON, N. J.

• SINCE 1920 • in the application, design and mfg. of pumps — separators — hydraulic accessories.

KRAISSL

Simplex & Duplex SEPARATORS

*USCG Approved

* Listed by Underwriters Laboratories

STRAINERS • FILTERS • STANDARD AND HIGH PRESSURE

ELIMINATE LIFTING JACKS

Kraissl Class 72 duplex separators are designed so that you don't need to use a lifting jack to raise the rotary plug valve. The valves are designed to a sufficiently wide angle taper — so that the plug does not wedge on its seat, through wear and use.

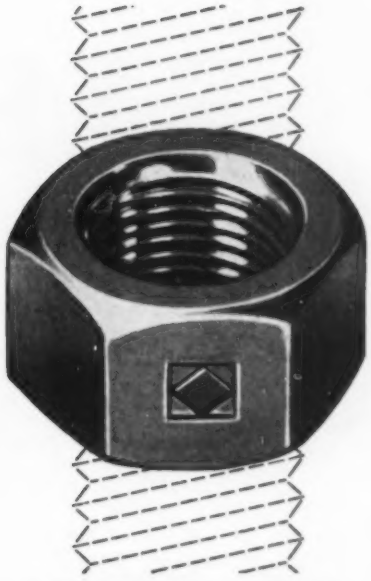
Grit, scale and extraneous abrasive matter settle on the seat face, from using a lifting jack. Then, when the plug is returned to its seat and the valve rotated, the seat is galled and scored. This terminates the serviceable life of your separators — and skyrockets your maintenance and overhaul costs.

Complete range of sizes — from 1¼" to 6"; pressures to 500 psi. Cast-iron, bronze, steel, stainless-steel, also aluminum, monel or special metals to your specifications.

Bulletin A-1214 gives full data — write for your copy today!

KRAISSL KRAISSL CO

289 Williams Ave. Hackensack, N. J.



HERE'S THE LOCK-NUT TO USE FOR AUTOMATIC ASSEMBLY...

The Republic Upson "Nylok*" Nut

12 WAYS BETTER

Assemble from either end
Can be re-used
Non-galling
Best wrenching characteristics
Won't damage threads
No special know-how
No special tools
One piece
Ideal for mechanical feeding
No lubricant needed
Cold-forged
Lock in any position

● You can feed Republic Upson "Nylok" Nuts mechanically at full production speeds through your automatic assembly lines. Or use them manually for piece-work assembly. There's no "This Side Up" to Republic Upson "Nylok" Nuts . . . they go on easily.

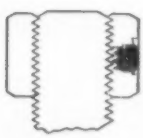
What's more . . . the nylon plugs keep these lock-nuts tight wherever you stop wrenching. And they are easy to back-off when the time comes. Can be safely *re*-used, too.

WRITE FOR SAMPLES, mentioning sizes required.

SIZES: Light series tapped ¼" thru ⅝" Regular series tapped ¼" thru ½"
Light thick series tapped ¼" thru ½" Heavy series tapped ¼" thru ½"

Investigate their advantages on *your* product

REPUBLIC STEEL CORPORATION
Bolt and Nut Division • **CLEVELAND 13, OHIO**
Export Department: Chrysler Building, New York 17, N.Y.



How the "Nylok" principle works...

A nylon plug inserted in one side of the cold-forged nut forces all the threads opposite the plug into tight metal-to-metal contact with the screw threads as the nut is turned on.

* U. S. Pat. No. 2,462,603 and pending applications

Republic UPSON QUALITY BOLTS AND NUTS

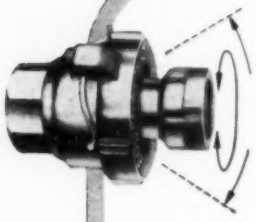
REPUBLIC STEEL

WHEREVER PIPING MUST MOVE

—a specialized BARCO flexible joint!

for angular motion—

— also swivel motion

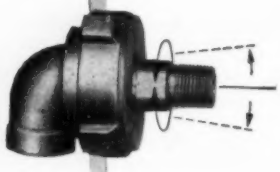


—BARCO BALL JOINTS

"*One joint does the work of two or more!*"—because it moves in any direction. Standard the world over where low cost, leakproof movable joints are needed in piping handling steam, air, water, oil, gas, or chemicals. Many models available. Up to 40° side flexibility *plus* 360° swivel action. Also used to facilitate quick connection of piping, overcome misalignment. Pressures to 7,500 psi; temperatures to 1,000°F. 15 different sizes, ¼" to 12". *Ask for Catalog No. 215.*

for swivel motion—

— also limited angular motion



—BARCO SWIVEL JOINTS

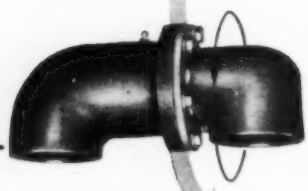
Self-aligning! Exclusive side flexibility (up to 10°) speeds up and facilitates installation; prevents binding. Widely used for making compact, low torque swivel connections to reciprocating or rotating parts on platen presses, tire molds, die casting machines, oil burners. Easy to position piping accurately—no sagging, flopping lines. Leakproof, safe—pressure or vacuum. Ratings as high as 600°F., 3,000 psi (hydraulic). Sizes, ⅜" to 2"; angle or straight. *Catalog No. 265*

for continuous rotation—

—BARCO REVOLVING JOINTS

Superior design insures trouble-free performance, minimum roll drag, and up to 50% power savings. Inherent low torque is little affected by increasing pressure, speed, or temperature. Parts are easily accessible. Light running action minimizes wear, permits free-floating installations. No adjusting necessary—long, leakproof service. Ratings to 250 psi (steam); 450°F. Single flow or syphon styles. Sizes ½" to 2" and special to 5". Wide choice of models. *For detailed information, ask for Catalog No. 300.*

for swing motion—



—BARCO SWING JOINTS

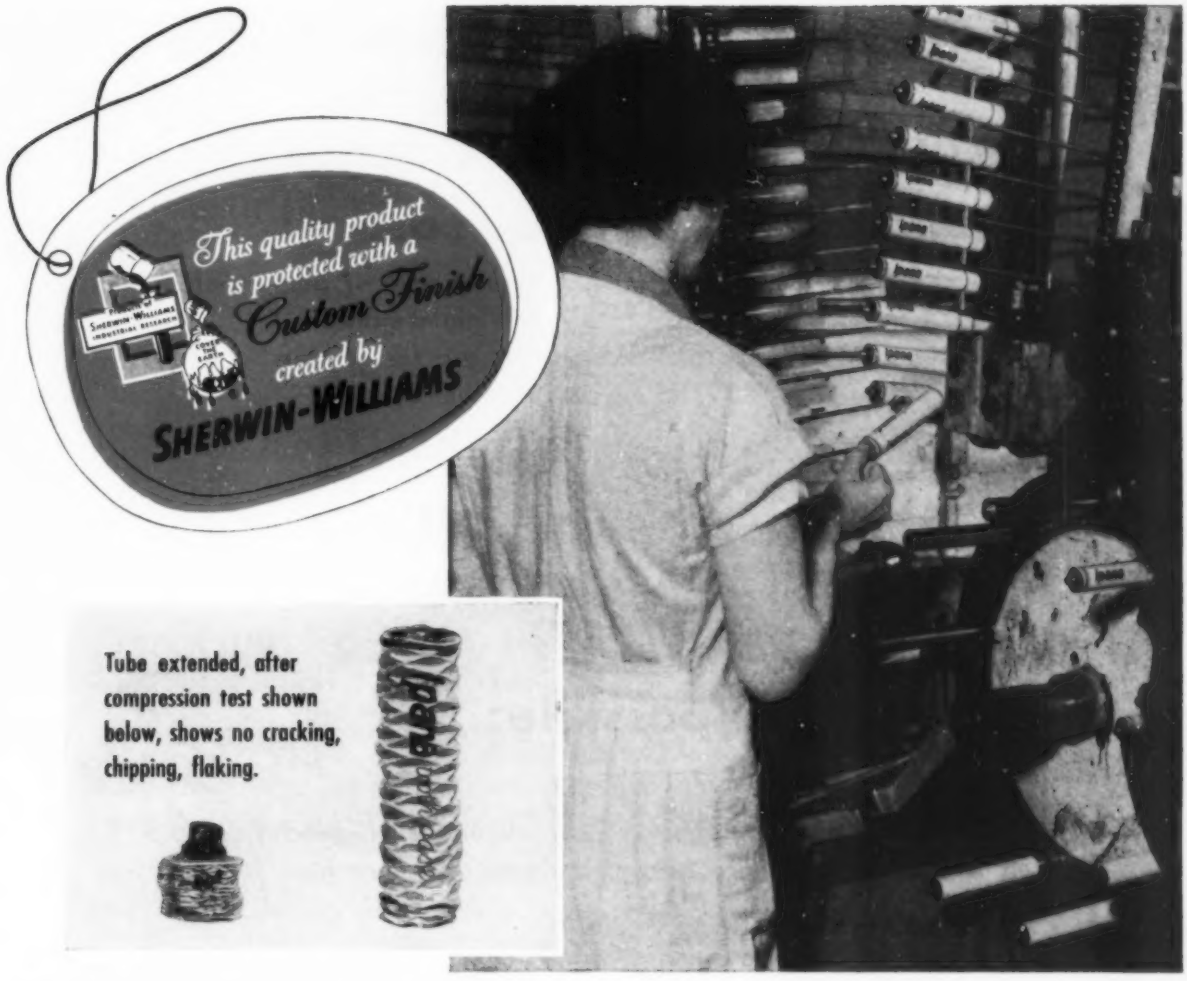
Barco's new line of ball bearing Swing Joints is complete with sizes and styles to meet every requirement on loading racks, fueling assemblies, and chemical applications. "O" ring gives long life, leakproof seal. Full bearing surface, swiveling 360° in one plane (single swing) or in two planes (double swing), supports normal piping. Ball bearings can't fall out. Built in steel for pressures to as high as 1500 psi (hydraulic); temperatures, —40° to 225°F. 11 styles: straight, angle, double angle, counter balance. Sizes 2", 2½", 3", 4". *Catalog No. 400.*

HIGH PRESSURE HYDRAULIC SWIVEL JOINTS—In addition to the four types of flexible joints illustrated above, Barco produces a complete line of High Pressure Hydraulic Swivel Joints for use with small diameter tubing or pipe. *Send for Catalog No. 269.*

BARCO *Manufacturing Co.*

527D Hough St., Barrington, Illinois (A Chicago Suburb) *In Canada: The Holden Co., Ltd.*

FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY



Tube extended, after compression test shown below, shows no cracking, chipping, flaking.

BIG SQUEEZE won't mar this finish

Ever squeeze a tube of shaving cream or tooth paste and have the paint flake off? That's what happens when ordinary finishes are used.

Sun Tube Corporation solved the problem for its customers. A Sherwin-Williams custom finish, applied under controlled conditions, practically fuses with the metal. The "big squeeze" you see here is proof . . . a myriad of accordion-like bends and sharp corners, yet the finish remains intact. Also, it has excellent chemical resistance.

Maybe you have a similar problem where flexing causes finish deterioration. Or perhaps you have a different problem, which can be solved with a specially formulated coating. Your Sherwin-Williams representative can offer qualified help . . . can bring you Sherwin-Williams' broad experience in providing the right finishing materials for widely varying requirements.

Ask him, too, about Sherwin-Williams identification aids—tags, seals or decals to help you feature the finish as a quality sales "plus". Or write for booklet B-767, "How to Make the Finish Help Sell the Product". The Sherwin-Williams Co., General Industrial Division, Cleveland 1, Ohio.

Another Product of SHERWIN-WILLIAMS INDUSTRIAL RESEARCH

COVER THE EARTH

SHERWIN-WILLIAMS

INDUSTRIAL FINISHES

COVER THE EARTH

SIMPLICITY in hydraulic pump design is important for these reasons:

The Pesco hydraulic pump is a gear design—the simplest of all hydraulic pumps. There are actually only three moving parts in the pump proper. Fewer moving parts mean—

. . . less chance of pump malfunction
. . . less maintenance
. . . less cost for overhaul
. . . less weight
. . . less noise

plus the EFFICIENCY of "Pressure Loading" which makes possible:

"*Pressure Loading*" is Pesco's exclusive development that *automatically* holds end clearance of gears to a thin film of oil, thereby maintaining the volumetric efficiency throughout the long service life of the pump.

. . . volumetric efficiencies up to 97% over a wide range of temperatures

plus STATISTICAL QUALITY CONTROL which assures:

. . . uniform high quality and performance of each pump
. . . a longer, trouble-free service life

Simplicity of design, *efficiency* of "*Pressure Loading*" and *statistical quality control* in all phases of manufacture, are three important reasons why Pesco pumps are standard equipment on military and commercial aircraft and on many automotive and industrial products. Write today regarding your hydraulic pump requirements.

engineering Pesco production
PRODUCTS DIVISION

BORG-WARNER CORPORATION
24700 NORTH MILES ROAD • BEDFORD, OHIO

Using Fellows Original Cutters...

"well under 1%"

Control Instrument Company of Brooklyn, New York, uses a Fellows 7-Type Gear Shaper to cut this 2.000" pitch diameter internal gear for a fire-control device to meet military specifications.

Using original Fellows cutters for both rough and finish cuts of this 4140 Chrome Moly steel, the number of rejects is exceedingly small. Control Instrument Company says, "... using Fellows cutters, our rejects are well under 1%".

The versatile Fellows 7-type is the most widely used size in Fellows complete line of Gear Shapers which generate gears from 1/16" to 120" diameter. It offers precision and high production on external gears up to 7" and internal gears up to 6" pitch diameter and 2" face width. Set-up is simple, and changeover on production runs is quick.

PRODUCTION DATA

Number of Teeth (Cutter) (Limited by projecting hub)	18
Number of Teeth (Gear)	96
Pitch	48
Pressure Angle	20°
Pitch Diameter	2.000 (+.002;−.000)
Run Out (Total Indicator Reading)	.001
Number of Cuts	2
Production Time (2 Cuts)	90 minutes
Blank Material	4140 Chrome Moly Steel

For helpful information on cutting coarse or fine pitch gears, cams, ratchet teeth, interrupted profiles, segment gears, face gears, racks, and other unusually high quality gears — just write, wire or 'phone the Fellows office nearest you.

Fellows

THE FELLOWS GEAR SHAPER COMPANY

Head Office and Export Dept., Springfield, Vermont. Branch Offices: 323 Fisher Bldg., Detroit 2; 5835 West North Ave., Chicago 39; 2206 Empire State Building, New York 1, N. Y.

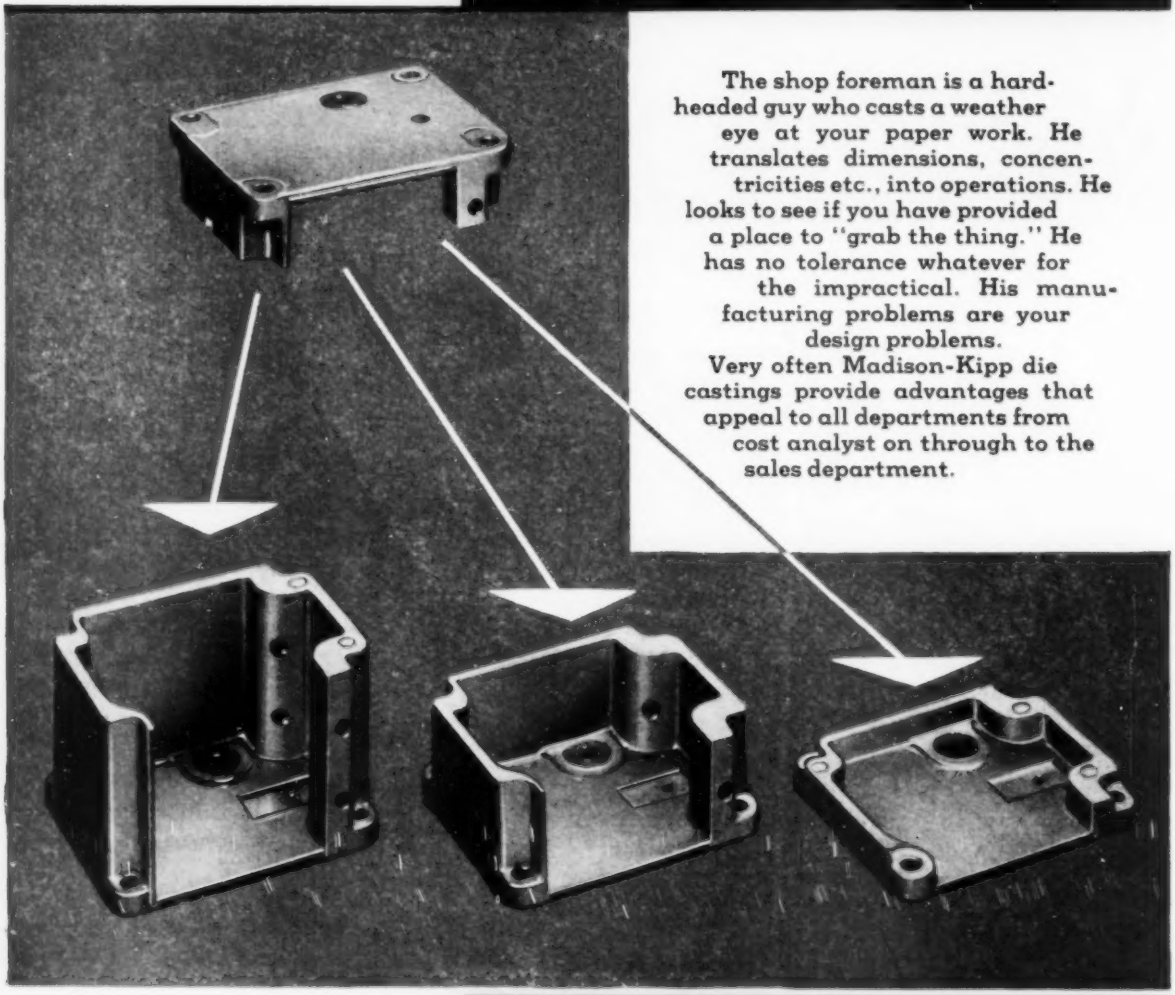
GEAR SHAPERS • SHAVING MACHINES • CUTTERS AND SHAVING TOOLS • GEAR INSPECTION INSTRUMENTS • THREAD GENERATORS • PLASTICS MOLDING MACHINES

A MASTER DESIGN *formula:*

To have your new design meet the approval of your shop foreman as well as the boss — because foremen know most about the practical side of your manufacturing equipment and personnel.

MADISON-KIPP ZINC AND ALUMINUM DIE CASTINGS

OFTEN PREFERRED BY DESIGNERS, MANAGERS, AND FOREMEN



The shop foreman is a hard-headed guy who casts a weather eye at your paper work. He translates dimensions, concentricities etc., into operations. He looks to see if you have provided a place to "grab the thing." He has no tolerance whatever for the impractical. His manufacturing problems are your design problems.

Very often Madison-Kipp die castings provide advantages that appeal to all departments from cost analyst on through to the sales department.

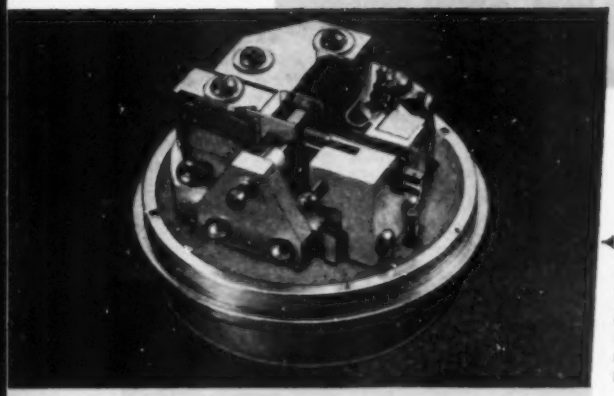
3 different instruments with 4 Madison-Kipp Die Castings — each with a special bearing insert — each casting with matching countours, locating points and centers, made for MICRO, Makers of Precision Switches, Freeport, Illinois.

MADISON-KIPP CORPORATION

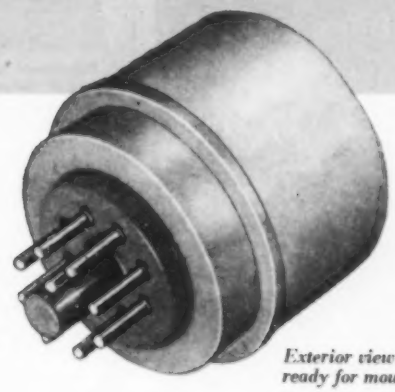
206 WAUBESA STREET • MADISON 10, WIS., U.S.A.

● Skilled in Die Casting Mechanics ● Experienced in Lubrication Engineering ● Originators of Really High Speed Air Tools

No ordinary relay...This! New CLARE Type T High Frequency Impulse Relay will follow 2500 cycles per second with life measured in billions of operations!



View of Clare Type T High Frequency Impulse Relay with dust cover removed



Exterior view of relay ready for mounting

specifications . . . .

MECHANICAL

SIZE: 1-15/16 in. diameter x 2-3/16 in. overall.
WEIGHT: 5 ounces.
MOUNTING: Equipped with mica-filled bakelite plug, to fit a standard 8-pin octal socket.
COVER: Removable dust-tight cover.
CONTACTS:
- **Type:** Form A (s.p.s.t., normally open)
- **Material:** Platinum-iridium
- **Gap:** 0.0005 inch
- **Pressure:** 30 grams, min. (Coil energized with 50 ampere-turns)

COIL:
- **Type:** Single winding, bobbin-wound
- **Wire:** Heavy formex

ELECTRICAL

COIL DISSIPATION: 0.5 watt (estimated max.)
CONTACT RATING: 0.05 amp., max. 50 volts ac, non-inductive. (estimated)
CONTACT BOUNCE: None
OPERATION:

Pull-in	15 ampere-turns
Drop-out	12 ampere-turns
Pull-in time	120 microseconds
Drop-out time	100 microseconds

RATE: Will follow 2500 cycles per second; aperiodic to 1000 cycles per second.
LIFE EXPECTANCY: 5×10^9 operations with zero contact current.
DIELECTRIC STRENGTH: 500 volts, rms.

TYPICAL APPLICATIONS

Coil inductance	0.3 hy (contacts open)
Coil inductance	0.35 hy (contacts closed)
Coil resistance	135 ohms
Pull-in current	10 to 12 ma.
Drop-out current	8 to 10 ma.
Normal coil current	40 ma.
Contact current	0.075 ma.

LIFE EXPECTANCY: Following a 1×10^4 operation run-in period, a life of 5×10^9 operations with a .075 ma. contact load over a 6-month period without readjustment.

Originally designed for use in an analog computer, the new CLARE Type T High Frequency Impulse Relay is now available for other applications which require a highly sensitive relay completely free from contact bounce and capable of a prodigious number of operations at extremely high speeds.

Its pull-in time of 120 microseconds and drop-out time of 100 microseconds enable this relay to follow up to 2500 cycles per second; aperiodic to 1000 cycles per second.

In a typical application, it has a life expectancy, following a run-in period of 1×10^6 operations, of 5×10^9 operations with a 0.75 ma contact load over a 6-month period without readjustment.

To achieve its high-speed, no-bounce, and other unusual characteristics, this relay is built to extremely close tolerances, with a high degree of precision, under conditions of utmost cleanliness. This necessitated the development of techniques never before employed in the manufacture of relays.

Even before this first public announcement of the availability of this truly remarkable relay, its fame has spread. Already dozens of inquiries and sample orders have been received from laboratories and development organizations which had learned of its existence through the manufacturer who first applied it in a well-known computer. It may provide the answer to one of your problems.

For full information on this new relay or for consultation on any relay problem, we invite you to contact your nearest CLARE sales engineer or write to C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13, Ontario. Cable address: CLARELAY.

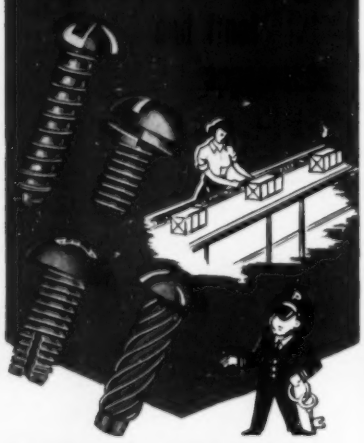
WRITE FOR BULLETIN 117

CLARE RELAYS

FIRST IN THE INDUSTRIAL FIELD

PRECISION MADE

PHEOLL SCREWS
BOLTS, NUTS and
Special Fasteners...



[redacted]TIME

Pheoll Screws, Bolts, and Nuts are easier to start, easier to drive and easier to tighten—because they're accurately machined and threaded. These features cut your assembly time and cost.

[redacted]GTH

The grain structure and flow of metal obtained through cold heading and roll threading increases the structural strength of Pheoll Fasteners. Cold working improves thread bearing surfaces, providing greater area of contact for firmer grip. Greater strength reduces possibility of shearing, and time lost in subsequent removal and retapping.

[redacted]CE

Step by step Pheoll inspection, through every process of production, assures uniform head size and shape; cleanly milled and recessed heads, neat chamfering and countersinking. All these factors contribute to the quality and finish which add materially to your product's final appearance. *Write* for Pheoll's product literature and price list.

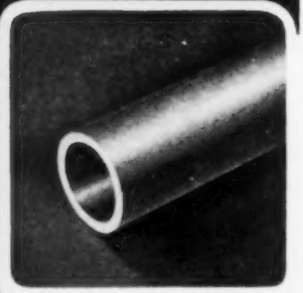
THESE PHEOLL PRODUCTS INCREASE YOUR PRODUCTION RATE. Thumb Screws Machine Screws† • Wood Screws† • Sheet Metal Screws† • Stove Bolts† • Rolled Threaded Wires and Studs • Special Rivets and Pins • Brass Washers

†*Furnished in slotted and Phillips Recessed Head Types*

PHEOLL SCREWS BOLTS

PROPER APPLICATIONS . . . *Product Improvement*
with
CUSTOM
EXTRUSIONS
by
H
and
R
INDUSTRIES

Adjustment strip for a welding helmet headband produced for Fibre Metal Products Co. of Chester, Pa.



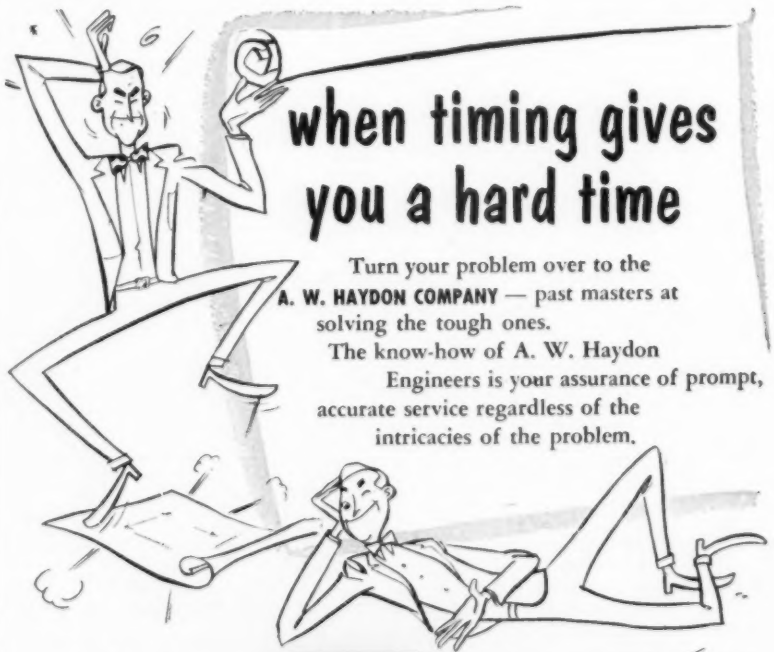
Corrosion resistant piping made to order for the Atlas Mineral Products Company of Mertztown, Pa.

Because of the properties required in the custom extruded products shown above, H & R used Kralastic, a modified styrene-butadiene, high in corrosion resistance and impact strength.

H & R offers a complete custom extrusion service capable of turning out the right plastic material in the exact form you need, at a price you'll appreciate. We are fully equipped to make all necessary dies for sheets, strips, rods, tubes and shapes.

Send us your problem—we'll be glad to send samples, recommendations and quote prices. Absolutely no obligation on your part.

H & R INDUSTRIES *Extruded Plastics*
NAZARETH, PENNA.



when timing gives you a hard time

Turn your problem over to the **A. W. HAYDON COMPANY** — past masters at solving the tough ones.

The know-how of A. W. Haydon Engineers is your assurance of prompt, accurate service regardless of the intricacies of the problem.

Send for catalog.

Would you like to work with us? We need qualified engineers *now*. Excellent opportunities for men who are looking to the future.

The A. W. HAYDON COMPANY
221 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Design and Manufacture of Electrical Timing Devices

Photo courtesy Marlow Pumps, Ridgewood, New Jersey

nearly 25% more water with Chrysler Industrial Power

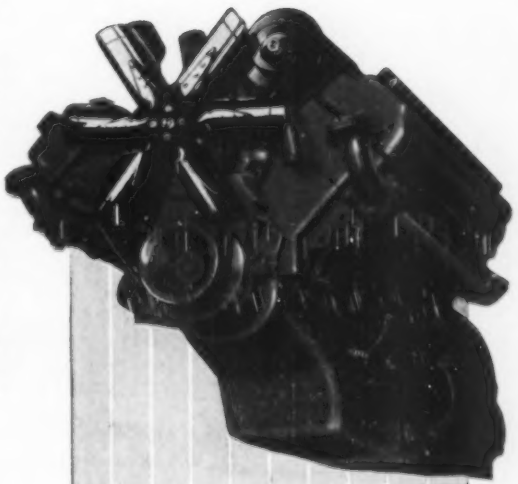
Too seldom does Mother Nature supply moisture in the right proportion for maximum realization of the good things of the soil. This problem is not confined to the so-called "dry" or "arid" regions of the country. For instance, here's a field of beans in upper New York State. This farmer, like many other farmers and growers, has found that a sprinkler system fed by a Chrysler-powered pump provides the supplemental irrigation necessary for best growth.

The Marlow Pump in use here is designed for high capacity pumping. For that reason, the powerful new 180 horsepower, 331 cubic inch displacement Model 20 Chrysler V-8 Industrial Engine was selected to power it. Result: nearly twenty-five percent more water than delivered by pumps powered by engines of similar weight and displacement, *without* sacrificing fuel economy.

This is another fine example of how Chrysler meets the many and varied requirements for industrial power. For instance, Chrysler can equip any of its engines with a corrosion-resistant or fungus-treated electrical system; propane or natural gas burning carburetor; 3, 4 or 5 speed transmission; standard or gyrol Fluid Drive.

Chrysler Industrial Power is not expensive. Production-line methods adapted to specialized industrial engine building provide a custom-built engine at mass-production prices.

For your power needs, see a Chrysler Industrial Engine dealer or write us direct: ***Department 43, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.***



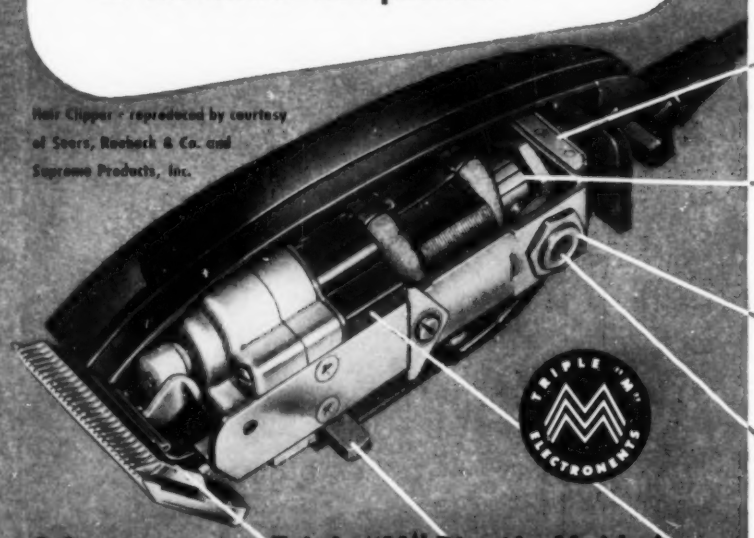
CHRYSLER

Industrial Engines

HORSEPOWER WITH A PEDIGREE

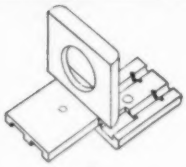
Here's how
Triple "M" Molded Plastics
meet requirements for:
✓ APPEARANCE
✓ PERFORMANCE
✓ STABILITY
in Electrical Components

Hair Clipper - reproduced by courtesy of Sears, Roebuck & Co. and Supreme Products, Inc.



Two Piece
MMMolded Phenolic Case

MMMolded Nylon Terminal Strips

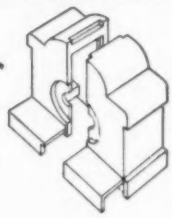


MMMolded Nylon (Copper shell) Commutator

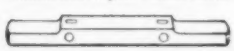
MMMolded Nylon Brush Holder (Brass insert)

MMMolded Nylon Brush Cap

MMMolded 2-piece Phenolic Fan Housing



MMMolded Nylon Switch Lever



MMMolded Nylon Bearing Rod

8 Components • Triple "M" Plastic Molded

Triple "M" Electronents are designed and produced by an organization skilled in meeting specifications. The hair clipper shown is an example of versatility in producing eight molded parts for structural and operating functions in the production of these components. Triple "M" uses specific types of plastics materials engineered for end-use performance. We want to work with manufacturers who want molded components built for the job. Let us know your requirements in

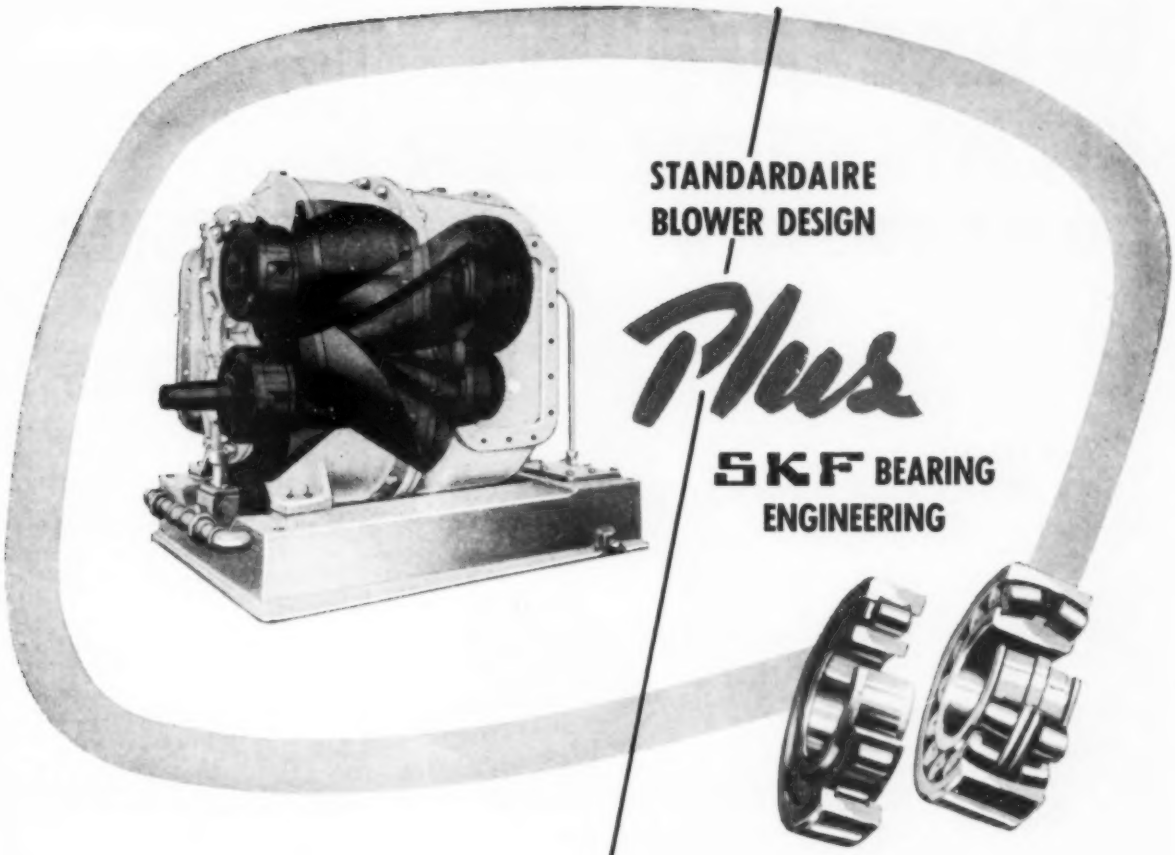
COMPRESSION AND INJECTION MOLDED PLASTICS

Midwest Molding AND Manufacturing COMPANY
Triple "M" Electronents Division
4628 Fullerton • Chicago 39

We are interested in: Molded Motor Parts ☐ Electronic Parts ☐ Custom Plastics ☐

NAME _____

Send this coupon attached to letterhead



STANDARDAIRE BLOWER DESIGN *Plus* SKF BEARING ENGINEERING

Every so often, a manufacturer has a chance to *prove* his wisdom in the selection of the product components he specifies.

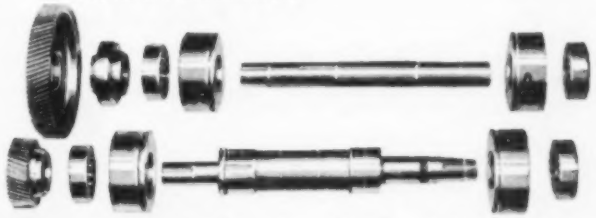
For example, Read Standard Corporation was able to obtain performance data on one of their "Standardaire" Blowers which had operated 24 hours a day, for 15 months, at 2200 rpm.

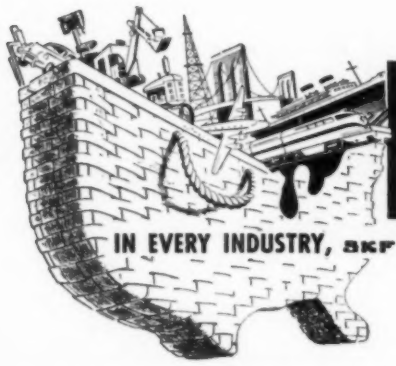
In other figures, that's about one and a half billion revolutions—representing many years' service for typical blower installations.

Even after the hard, difficult service, this blower and bearings were found to be in excellent condition when dismantled and inspected in the presence of Read Standard customer's representative.

Performance like this is proof of sound *design*—proof, too, that the designers selected the best available materials and component parts . . . among these were SKF Bearings.

Here we quote from the "Standardaire" Blower performance report: "Anti-friction bearings in good condition." They were SKF Cylindrical, and Spherical Roller Bearings, designed into the gate rotor shaft and main rotor shaft as shown in the illustration.





SKF®
BALL AND ROLLER BEARINGS

IN EVERY INDUSTRY, SKF Puts The Right Bearing In The Right Place

Remember—if you want design assistance and engineering help when you're laying-in bearings, you can get it from SKF field or home office men who know the best ways to do the job in every industry. **SKF INDUSTRIES, INC.,** PHILADELPHIA 32, PA.—*manufacturers of* **SKF** *and* HESS-BRIGHT *bearings.*

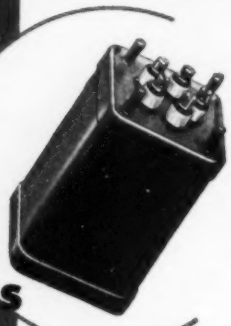
7323

WHEELER TRANSFORMER COMPONENTS

now available in

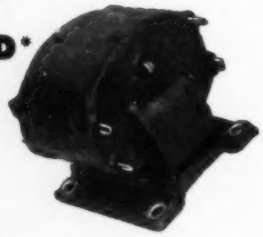
standard MIL-T CASE SIZES

Improved can construction induction solder assembled in rigid compliance with applicable specifications.



FOSTERITED* UNITS

Wide variety of available brackets for laminated and Hypersil core assemblies.

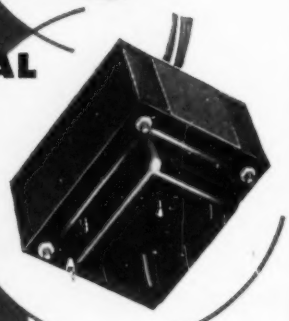


SPECIAL CONSTRUCTION

Available in the "0" to #3 round can series with color coded ceramic bead terminal bonds induction solder assembled.

COMMERCIAL

Can we assist you in maintaining your proportionate level of commercial business requiring wound coil components?



*©Westinghouse Elec. Mfg. Co.

WHEELER

MAGNET WIRE
COILS
COMMUNICATIONS EQUIPMENT
TRANSFORMERS

MAKES THESE PRODUCTS A *Specialty*

THE WHEELER INSULATED WIRE COMPANY, INC.

Division of The Sperry Corp. • **1103 EAST AURORA ST., WATERBURY 20, CONN.**

How to Benefit From Double-Purpose

TEXTURED ORGANIC COATINGS

8 pages—25 cents a copy

Textured organic coatings serve the double purpose of protecting metals and furnishing finishes of unusual eye-appeal. These coatings are extremely useful as they obscure marks left on metallic surfaces by production and finishing operations effectively with one coat.

All the latest information on these "special effect" coatings is available to you in this report. Included is an invaluable chart showing suggested uses, application methods, properties, and color possibilities.

Copies of other reports in this series on improved product appearance and protection are also available.

WHICH COATING FOR GRAY IRON?
8 pages—25 cents a copy

IDENTIFYING YOUR PRODUCT
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SELECTING ORGANIC COATINGS FOR METAL PRODUCTS
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PHOSPHATE COATINGS FOR MILITARY PRODUCTS
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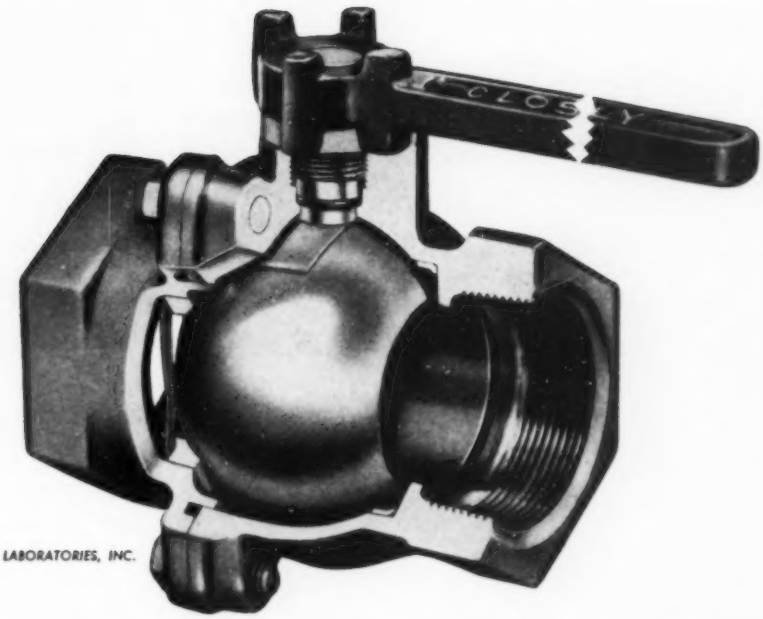
WRITE TO READER SERVICE DEPARTMENT:

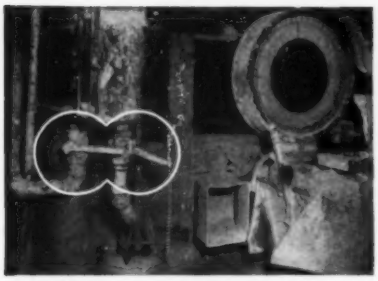
Product Engineering
McGraw-Hill Building
New York 36, N. Y.



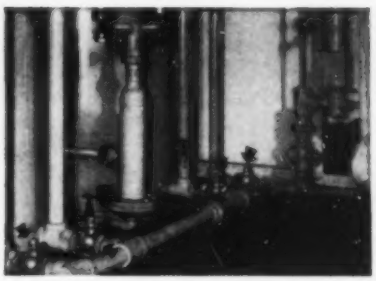
TESTED BY UNDERWRITERS' LABORATORIES, INC.

Breaking Records Throughout Industry!

FOR LONG LIFE . . . FOR ECONOMY . . . FOR SAFETY



Leading glass manufacturer reports Rockwood Ball Valves, operated 1500 times a day in a mixing process, were *only valves to stay in service over a year.*



Maintenance engineer of large gas company says: "Easy operation and no maintenance cost make Rockwood Ball Valves *far ahead of any others we have used.*"

On Texas transport firm's fleet of propane-butane trucks, the leakproof construction of Rockwood Ball Valves make them *safest for handling inflammable gases.*

Here's why Rockwood Ball Valves give you more of what you want in valve performance:

FULL ROUND FLOW . . . no change in shape or volume of the fluid stream . . . no turbulence . . . minimum friction loss.

QUICK OPENING AND CLOSING . . . needs only a quarter turn, even under full pressure.

RESISTS WEAR LONGER . . . scratching, pitting and abrasion have little effect on the chrome-plated, floating bronze ball.

STAYS LEAKPROOF . . . in closed position, pressure of fluid automatically positions ball against synthetic rubber seat to form a tight seal.

It will pay you to investigate how these advantages can benefit your own applications. Send for bulletin. Rockwood Sprinkler Company, 106 Harlow Street, Worcester 5, Mass. Distributors in all principal cities.

Some Prominent Users

Libby-Owens-Ford Glass Co.
Revere Copper & Brass, Inc.
Bird Machine Co.
Remington Rand, Inc.
Hub Machine Co.
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Also approved by Und. Lab. for L. P. G.

ROCKWOOD *FULL-FLOW* BALL VALVES

THE FLOW IS AS ROUND AS THE PIPE ITSELF

SHENANGO Centrifugal CASTINGS ... KEY TO SAVINGS

How to save time and money on symmetrical parts!

YOU are in line for a double advantage when you turn to Shenango for symmetrical, tubular or annular parts, large or small.

First, such parts are produced by Shenango's advanced centrifugal casting process. This means *tougher* parts because of finer, pressure-dense grain, greater strength, better elongation and freedom from sand inclusions, blow holes and other often hidden defects. It also means less waste, less machining.

Second, Shenango has the modern machining facilities and skilled workmanship to give you semi-machined or finished parts... precisely as specified... at minimum cost! The heavy trunnion bearing shown above is one of the many types of parts, large and small, ferrous and non-ferrous, regularly produced at Shenango.

FREE BULLETINS

Find out if Shenango can help you save time, money and material. Bulletin No. 150 covers non-ferrous centrifugally cast parts; Bulletin No. 151 for parts of Meehanite Metal and Ni-Resist. Either or both are yours for the asking.

SHENANGO-PENN MOLD COMPANY
Dover, Ohio
Executive Offices: Pittsburgh, Pa.

SHENANGO

ALL RED BRONZES · MANGANESE BRONZES · ALUMINUM BRONZES
MONEL METAL · NI-RESIST · MEEHANITE METAL

650° F.
STEADY OR WITH RAPID FLUCTUATIONS
MYCALEX INSULATION CAN TAKE BOTH OF THOSE TEMPERATURE CONDITIONS

It holds inserts tightly, and moves with the metals around it, because it has very nearly the same coefficient of thermal expansion as the most important metals of which inserts and casings are made.

DESIGNER! UNCHAIN YOUR IMAGINATION!

The destructive effects of high operating temperatures, high ambient temperatures, thermal expansion as between metals and insulations, have caused you to make too many items too much bigger and heavier than they need to be.

MYCALEX glass-bonded mica also is dimensionally stable, corona resistant, does not carbonize under arc, has no moisture absorption.

THERE ARE PLENTY OF OTHER USEFUL FEATURES . . . WRITE for the whole story

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THE INSULATOR ®

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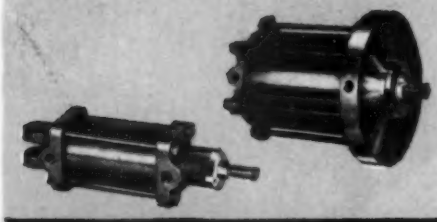
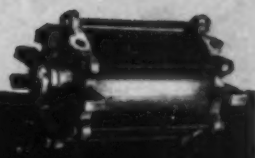


Pneumatic Cylinders



NOW...

HANNIFIN HAS THE MOST COMPLETE LINE OF AIR CONTROL EQUIPMENT!

Really complete, the Hannifin line of pneumatic cylinders is made with two types of pistons . . . bores from 1" to 16" . . . six standard mountings. Really standard, these cylinders are tooled to tolerances that assure accurate mounting to make assembly to your machines easier. Really built, each cylinder is "TRU-BORED" and honed, piston rods are ground and polished, interchangeable end caps, heavy duty tie rods . . . rugged, yet precision construction throughout!

Write for Bulletin 210

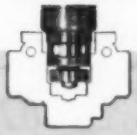
NEW! REVOLUTIONARY HANNIFIN *P-M Pilot-Master Valves*

Piston-operated poppet design. Exclusive replaceable cartridge for easier maintenance. Speeds to 600 cycles per minute. Pressure from 15 to 150 p.s.i. Integral, solenoid-controlled pilot heads or a choice of 10 separate pilot valves for remote control.

- Fewer Valves to Stock
- Fewer Parts to Stock
- Maximum Interchangeability
- No Springs in Main Valve

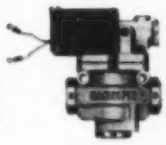
Write for Bulletin 231.

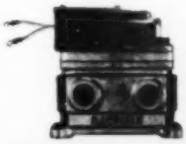
EXCLUSIVE REPLACEABLE CARTRIDGE



2 and 3-Way Valves.

Same valve operates 2-way or 3-way, normally open or normally closed. ⅜" to 1¼" I.P.S.





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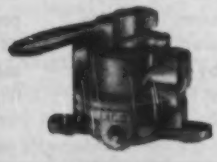

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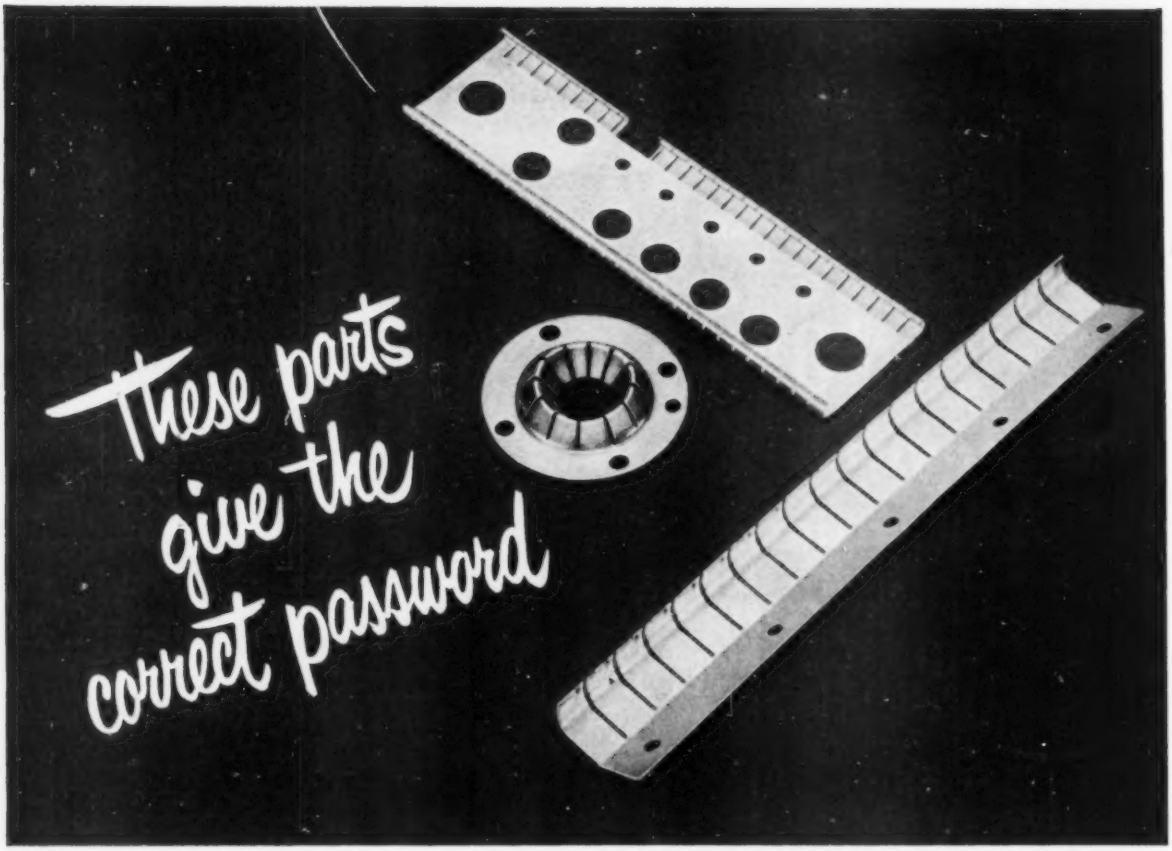

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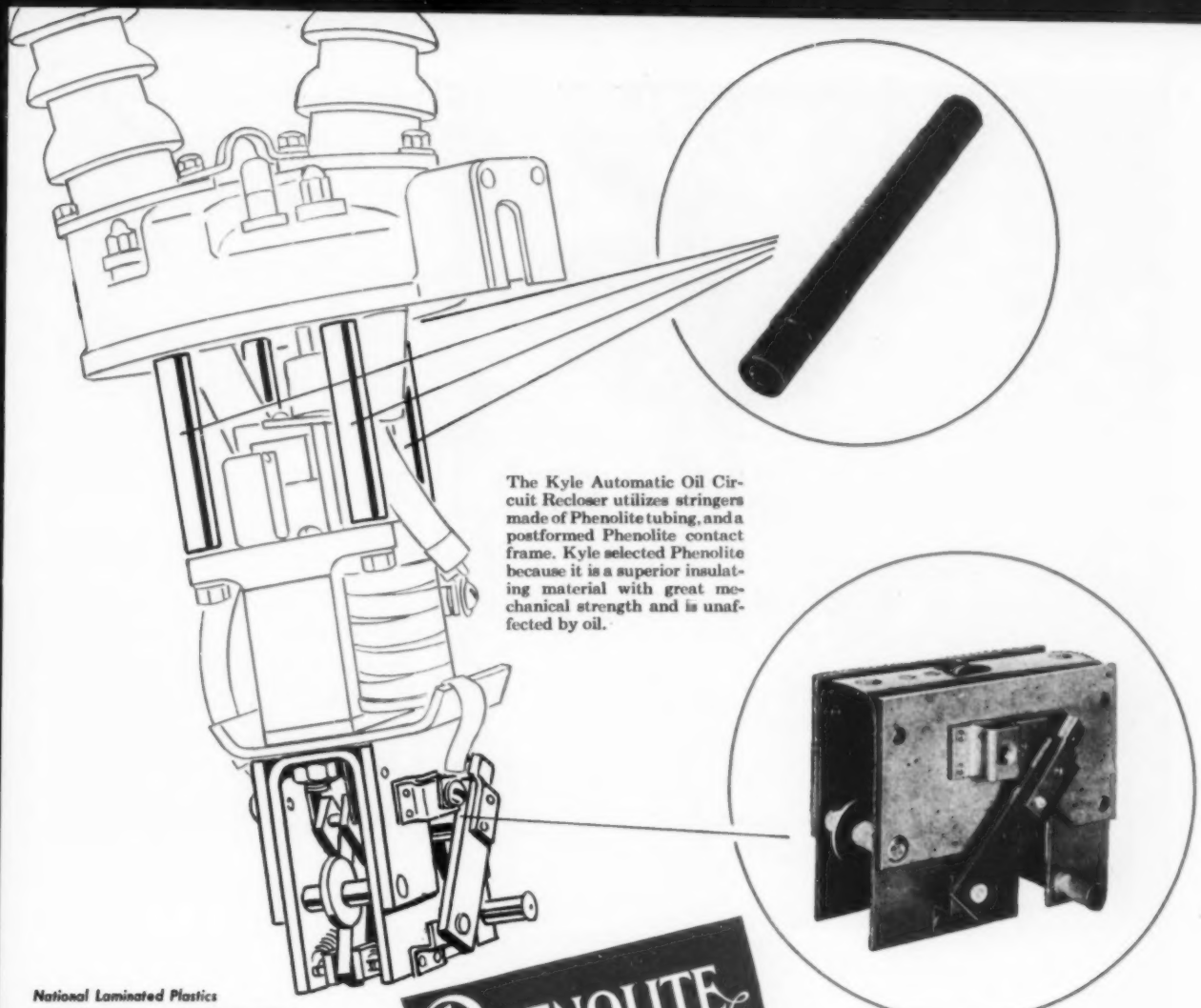

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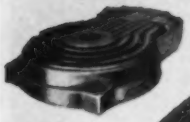

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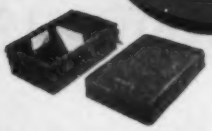

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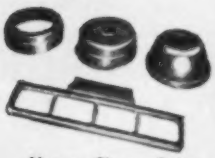

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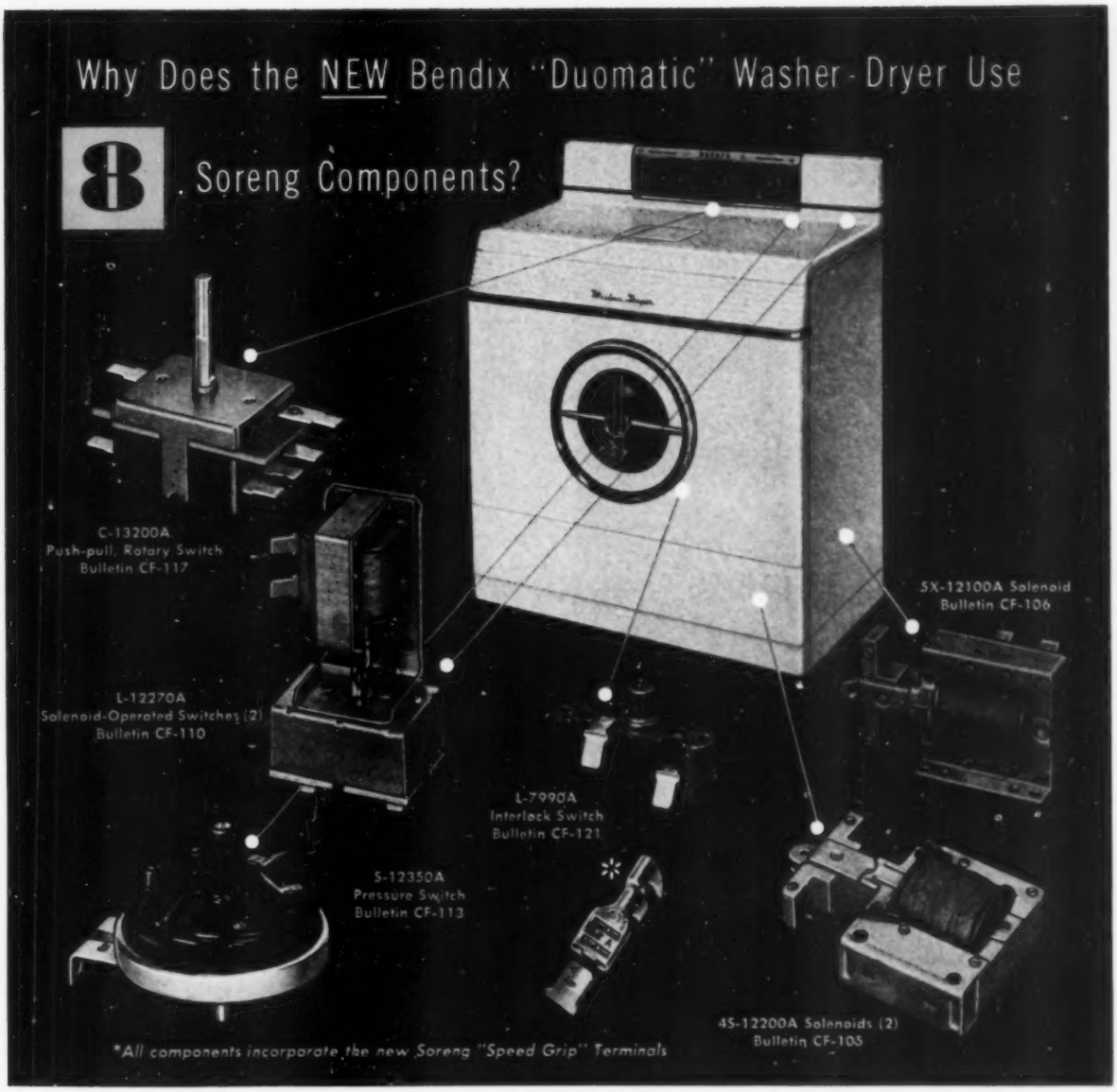

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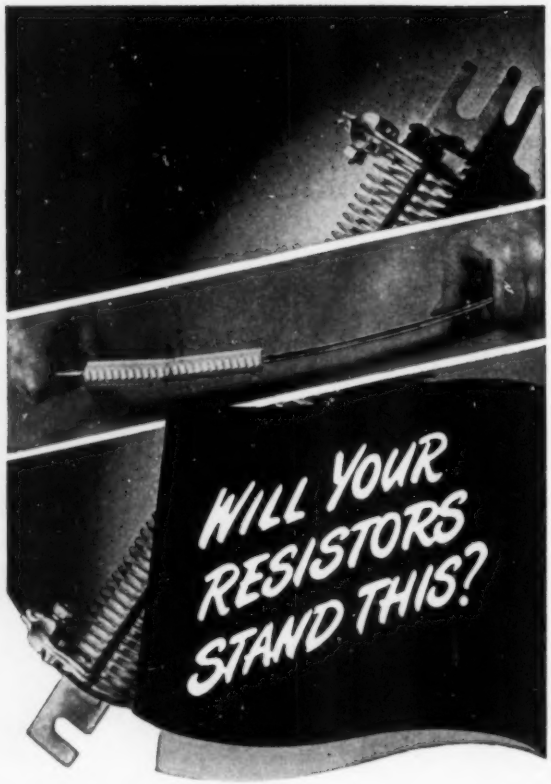

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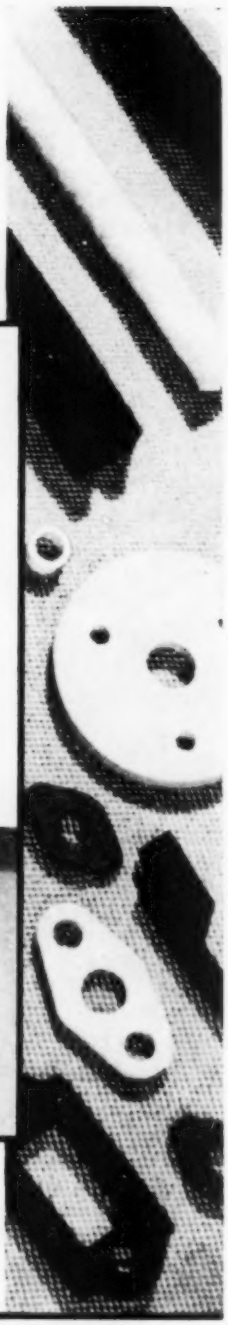

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Honeywell controller regulates flow of cooling water

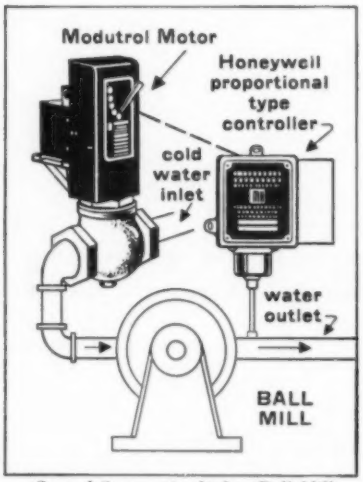
As paint is ground in steel ball or pebble mills, considerable heat is developed. The resulting temperature variations can change the efficiency of grinding—with corresponding effects on quality of paint.

The control system which Western Paint and Varnish Co. of Duluth, Minnesota, has worked out is simple but effective. Water running through the cooling jacket around the grinding mill takes away the heat of grinding. But since the process continually produces more heat, less water is needed at the start than at the end of the run.

A Honeywell remote bulb proportioning type controller is installed with its bulb in the outlet water line. The controller regulates water flow, by means of a *Modutrol* motorized valve in the incoming cold water line.

Proportional control action keeps water temperature steady throughout the process. As the grinding heat increases, outlet water temperature starts to rise. The controller then calls for more water by directing the *Modutrol* unit to open the valve further. The net result is that temperature never fluctuates more than a few degrees . . . grinding conditions stay at the right values to produce consistently high production quality.

The simplicity of this arrangement is typical of the ways that the more than 7000 Honeywell control devices can be utilized in an endless variety of applications. And these controllers are completely dependable; they're ruggedly built in every detail . . . and they're backed by Honeywell's nationwide service organization.



Control System Applied to Ball Mill

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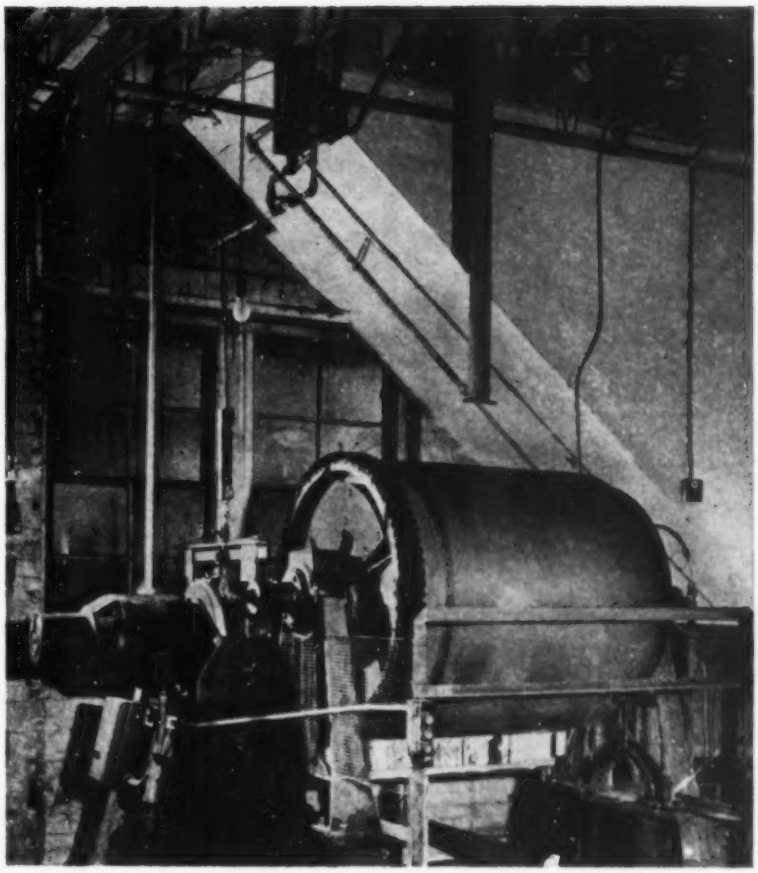

Paint grinding improved by Honeywell temperature controller

Holding accurate temperatures in a paint grinding mill makes a big difference in quality of paint. But, as the Western Paint and Varnish Co. found, a simple Honeywell remote bulb temperature controller coupled with a matching *Modutrol* motorized valve can do this job economically—and with ample precision to assure top efficiency.

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for FASTER ASSEMBLY ON

Millions of pounds in daily use

Radio Tubes

Many of the country's largest tube manufacturers use Sauereisen Insa-Lute Adhesive Cement No. 1 to cement ceramic insulation on tube mounts. Other leading electrical concerns use Sauereisen Cements for sealing, embedding and insulating. They not only cut production costs but improve product quality. Send unassembled parts or drawings for help in selecting the right cement for your purpose.

TRIAL ORDER { 1 GALLON SAUEREISEN INSA-LUTE ADHESIVE CEMENT NO. 1 ..... Test under your own conditions } **$4.18**

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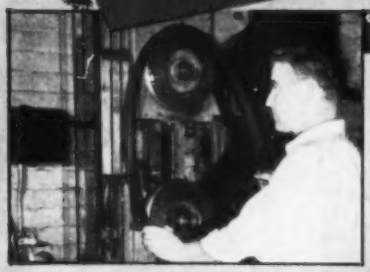
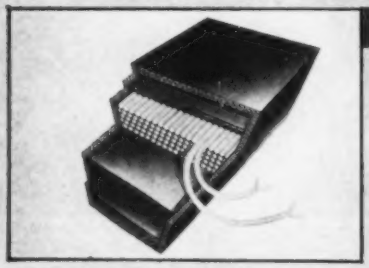
DURKEE ATWOOD V-BELTS

EXTRA VALUES for PRODUCTS designed USING "V" BELTS



VERTICAL MATCHING ASSURES EQUAL POWER TRANSMISSION

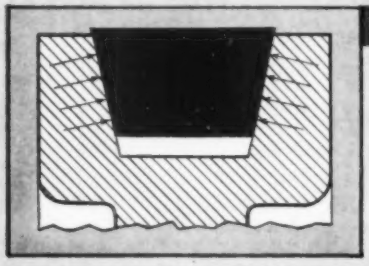
Durkee-Atwood's new vertical V-belt matching machines eliminate the "sag" error always present when V-belts are matched on horizontal matching equipment. Calibration of true running length assures equal power transmission from all belts on multiple belt drives. The machines also test for vibration and possible internal imperfections.



DU PONT CORDURA® RAYON MULTIPLE CORD CONSTRUCTION

High-tenacity Cordura® rayon cords give Durkee-Atwood Industrial V-Belts longer life, less stretch, and greater shock resistance. Use of this revolutionary new cord material is another one of the reasons why D-A Industrial V-Belts are guaranteed to satisfy on any drive.

®Trademark E. I. Du Pont De Nemours & Co., Wilmington, Del.



STRAIGHT SIDEWALLS—FULL GROOVE CONTACT

Durkee-Atwood V-Belts are manufactured with straight sidewalls to maintain full groove contact at all times giving positive drive action. Straight sidewalls reduce slippage and assure smooth, efficient power transmission. The load is distributed evenly over the entire thickness of the belt giving it longer life.

FIELD-TESTED AND APPROVED

Durkee-Atwood V-Belts are delivering the power for more nationally used products from steak tenderizers to rock crushers because more product designers have had occasion to check their quality in use. Durkee-Atwood gives extra attention to specific engineering needs as well as delivery requirements to make Durkee-Atwood an excellent source for your V-belt requirements. Conveniently located warehouse stocks and ample representation assures fast attention to your inquiry.

New Warehouse Stocks • Chicago, Atlanta, Cleveland, Jersey City

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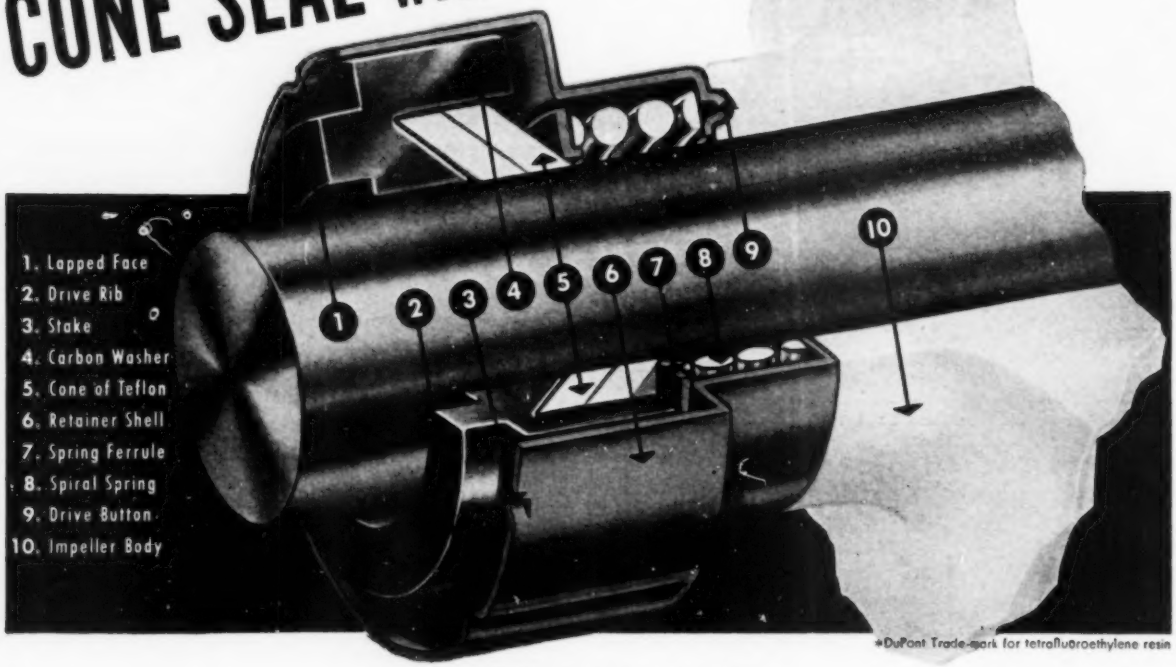
MINNEAPOLIS 13, MINNESOTA

DURKEE ATWOOD V-BELTS

DA PRODUCTS SINCE 1910

Form No. 541

BRAND NEW CONE SEAL with TEFLON*



*DuPont Trade-mark for tetrafluoroethylene resin

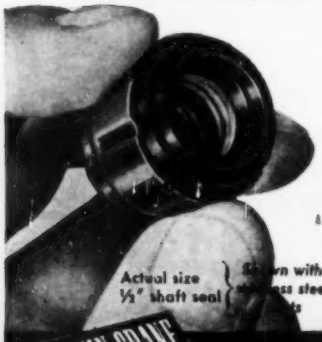
The All-Purpose Seal

For life-time performance in small pumps, hot water circulators and many other rotary shaft seal applications

Temp. −100° F. to +450° F. WATER-OILS-ACIDS PRESSURES 200 PSI

ADVANTAGES •• "JOHN CRANE" TYPE 19 CONE SEAL WITH TEFLON

1. Cones of Teflon will not deteriorate under −100° F. or +450° F.
2. Cones of Teflon are not attacked by any acid.
3. Cones of Teflon seal tight on shaft and in carbon washer, low pressure or high pressure.
4. Cones of Teflon stay put and have long life.
5. Type 19 Sealing Unit (with Teflon) has all the requirements of a good seal: positive drive, axial and radial movement, free sliding flexible spring action to compensate for wear of carbon washer, ease of application and replacement, long life, compactness.
6. Type 19 Sealing Unit (with Teflon) is a packaged seal, presently designed for small shafts ¼, ⅜, ½, ⅝, ¾" dia.
7. Type 19 Sealing Unit (with Teflon) is tooled for the high production field. It has a wide field of application.
8. Type 19 Sealing Unit (with Teflon) can be manufactured at an economical price.
9. Type 19 Sealing Unit (with Teflon) is manufactured in the "pressed-in" type where seal unit is held stationary.



SPECIAL NOTE

Teflon is the answer to the automotive and aircraft engineer's specification for an extremely low and high temperature range. It is fast replacing rubber parts which have a tendency to harden, crack, soften, or otherwise fail.

In the early stages of any seal application we might be helpful. For instance—the metallurgy of a seal is important; you may have space limitations or you may have r.p.m. problems. These are only a few points. Drop us a line.

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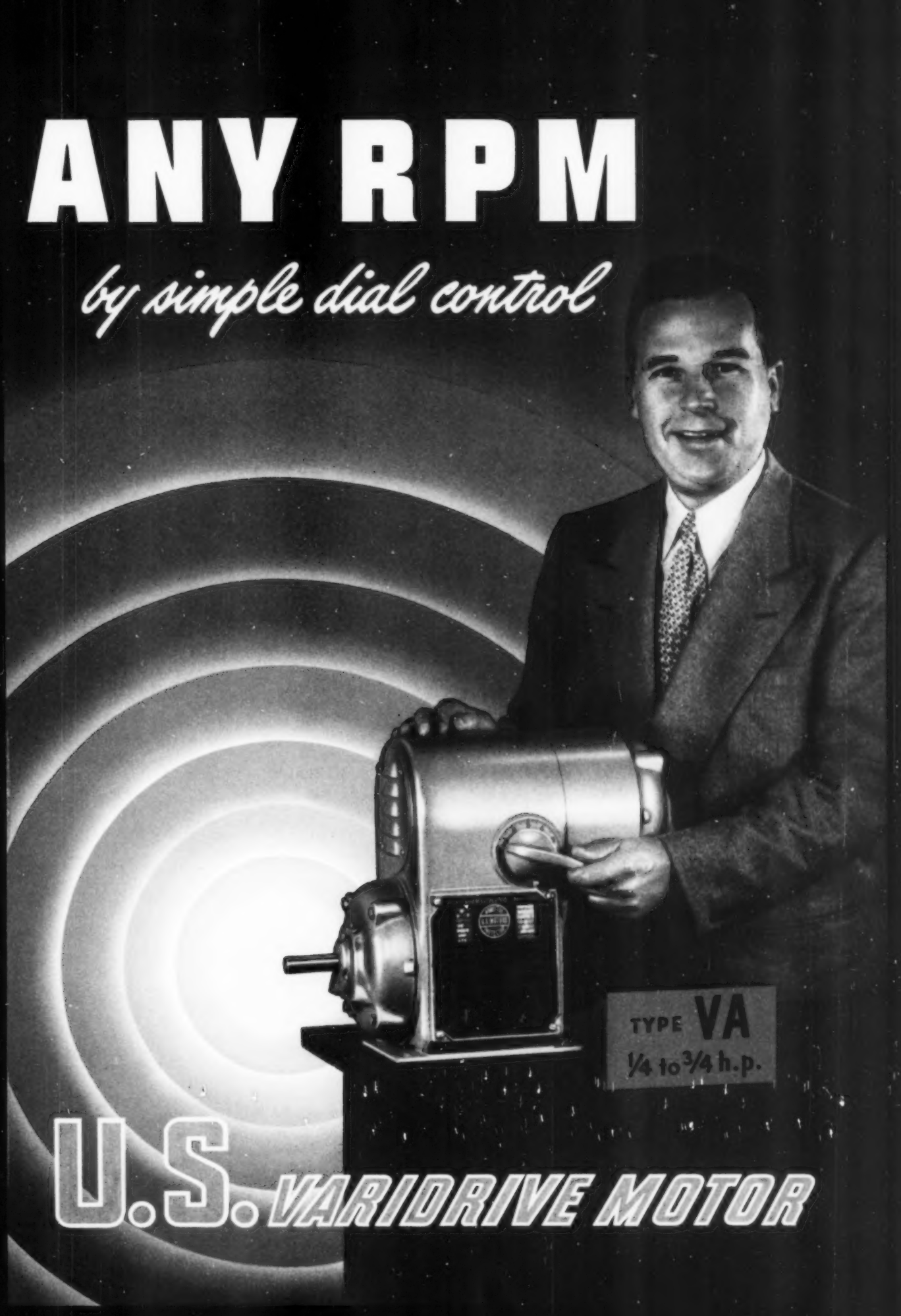
by simple dial control



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The miracle motor for VARIABLE SPEED

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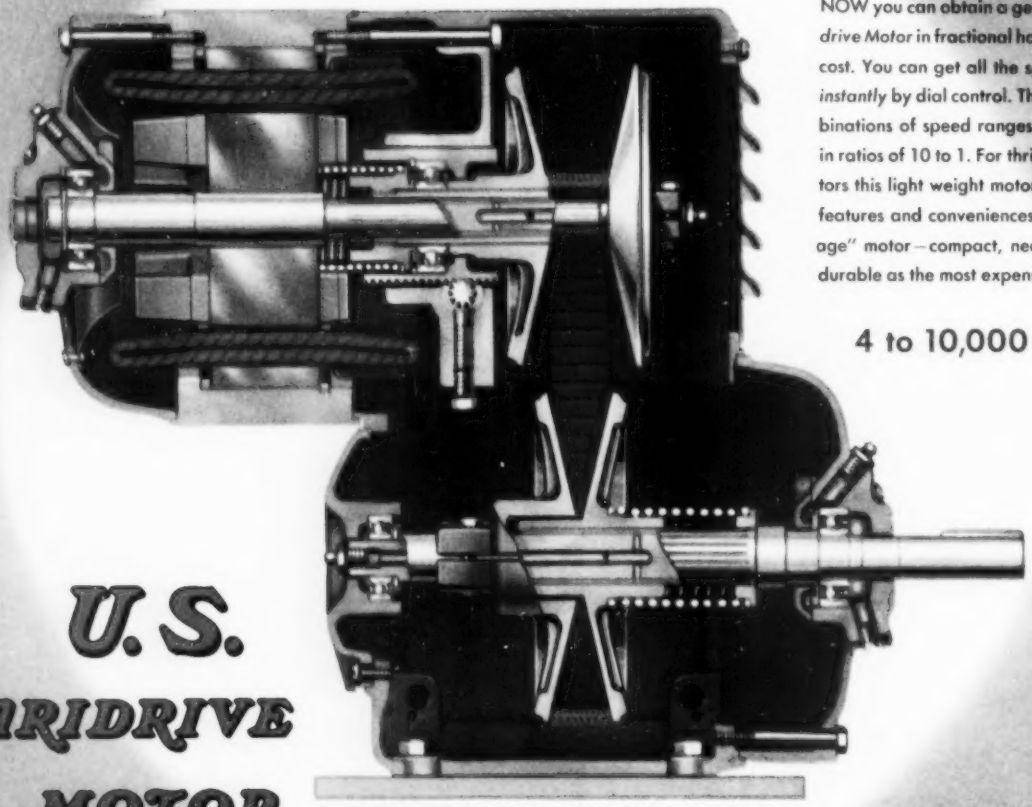

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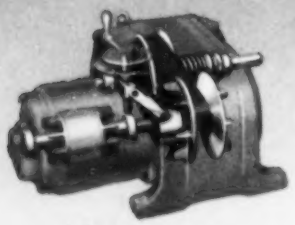
4 to 10,000 r.p.m.

U.S. VARIDRIVE MOTOR

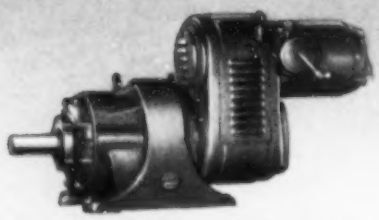
TYPE VA — 1/4, 1/3, 1/2, 3/4 hp

OTHER U.S. VARIDRIVE MOTORS, UP TO 50 H.P.



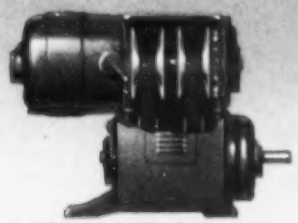
TYPE VE VARIDRIVE

Horizontal type. Take-off shaft can be positioned left or right. All Varidrives embody asbestos-protected windings, normalized castings, Lubri-flush bearings and centricast rotor.



TYPE VEV-GD WITH SYNCROGEAR

Combination type embodying Syncrogear, for extra low speeds and high torque. Varidrive unit is mounted on Syncrogear, upright as shown above, or can be set horizontally.



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For extra heavy duty in larger capacities, dual belts are provided. Explosion-proof types and electrical or mechanical remote control also available in horizontal and upright models.

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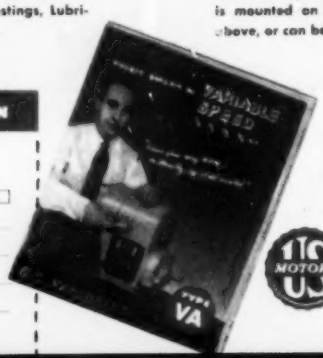

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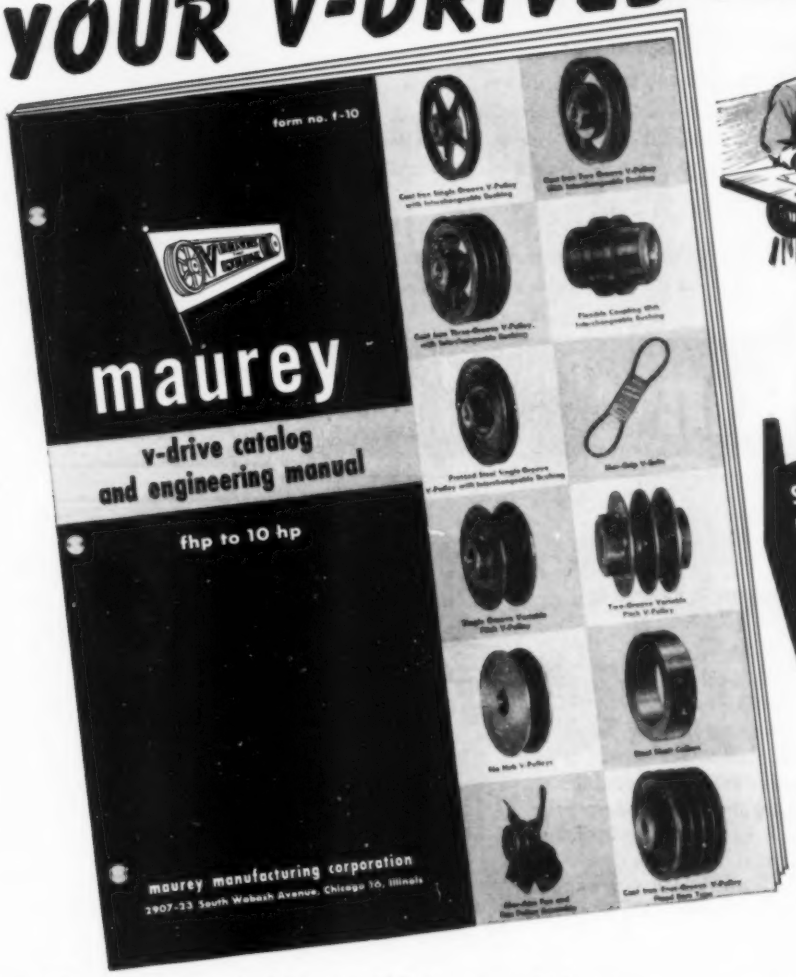
For Your Product Data . . .

THIS BOOK BELONGS IN YOUR V-DRIVES FILE



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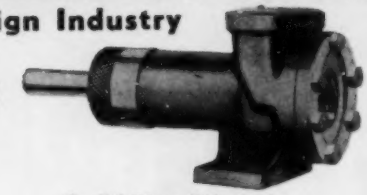

Fig. 54 (½ to 3½ gpm)
Foot Type Unmounted Pump

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Capacities ½ to 1050 gpm
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Pressures to 500 psi on sizes to 3½ gpm
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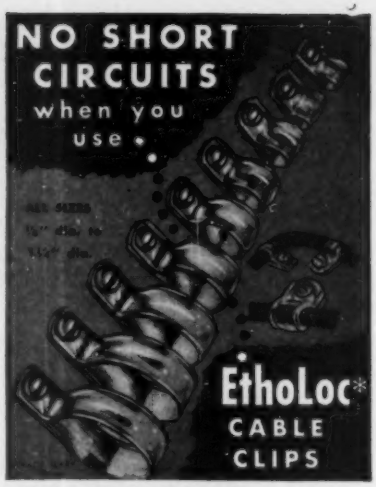

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	1FR	
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Shellers	1FR	3DR
Snow Plows	3DR	35N
	L14N	
Sprayers	35N	3DR
	1FR	
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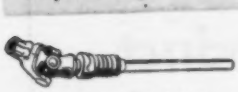
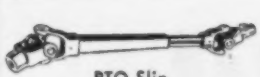
K2R	3
L6S	4
L6N	5
L10S	5
1FR	10
L14S	11
3DR	15.7
L16S	19
L14N	30
35N	50

You can get joints alone or assembled with fixed or slip joint shafts... with or without integral safety shields, safety clutch, clamp yokes... or with the popular, salable quick-detachable yokes.


With Safety Clutch

1FR Series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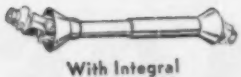
L6S Series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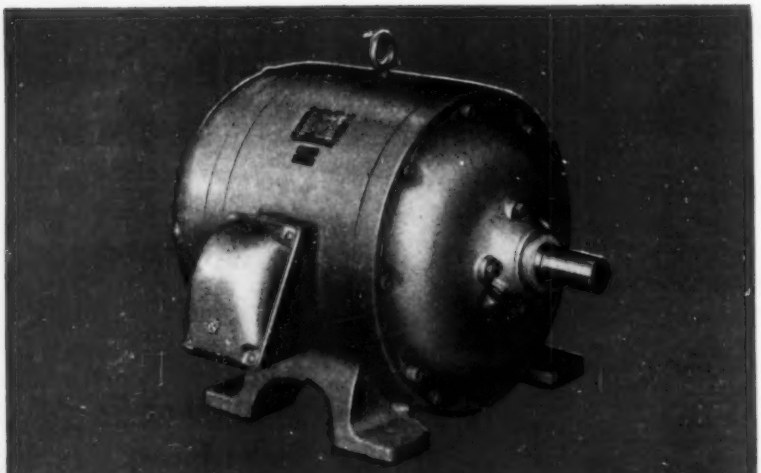

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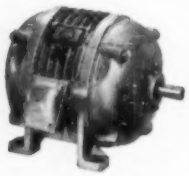

SMITHway totally enclosed non-ventilated motor. Standard NEMA frames. Cast iron construction of all exposed parts keeps these motors, by the thousands, on the job regardless of dust, dirt and corrosive conditions. Available in ratings from 1 to 5 HP.

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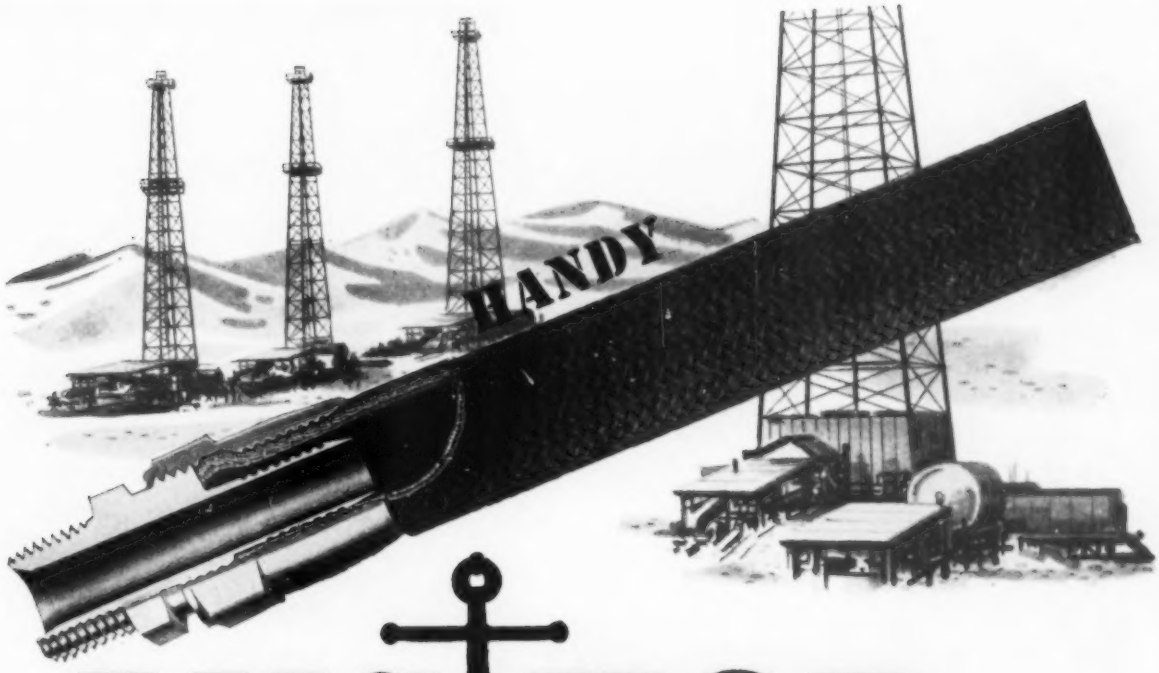

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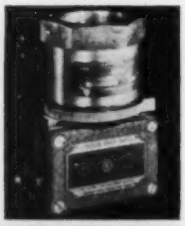

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They operate in any position, are not affected by vibration, have extreme repetitive accuracy.

For complete technical information see our catalog in Sweet's 1953 File for Product Designers and in the Plant Engineer's File, or write for catalog 2M-S.

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(MEETING ASTM SPECIFICATIONS)

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For the convenience of manufacturers, DUTCH BRAND Sponge Rubber is now made available to industrial distributors, on a stocking basis.

DENSITIES

Natural Rubber	ASTM SPECIFICATIONS No. D1056-51T
No. 3832 Soft Density	RN11
No. 4022 Medium Density	RN12
No. 4030 Firm Density	RN13
No. 4031 Hard Density	RN14
Neoprene	
No. 3399 Soft Density	SC11
No. 3394 Medium Density	SC14

COLORS

1. Brown 2. Gray 3. Red 4. Green
5. Other colors available where quantities warrant

THICKNESSES

1/8 inch to 1 inch inclusive

SIZES

Rolls, sheets, strips with or without adhesive . . . die cut pieces.

DUTCH BRAND

VAN CLEEF BROS. INC.

Manufacturers of Rubber Products

DIVISION OF Johns-Manville

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Luxolene Green

a new advancement in moisture-resistant coils

Luxolene Green molded coils have been engineered especially for applications involving intense moisture conditions, such as in refrigeration, air conditioning, water pumping, etc. . . . also for explosion proof applications.
Field tests of production coils have proven more than satisfactory.
The cost of Luxolene Green encased coils is nominal. Send for complete information.

(NOTE: Deluxe Coils, Inc., manufactures coils only—no complete transformers, relays, solenoids, etc.)

ENGINEERING DATA

COIL CONSTRUCTION: Random, paper layer or precision wound.

Excellent Bond { Lead Wires 105°C Polyvinylchloride U.L. approved; Molding Compound—Luxolene Green Resin; Core Tube—Luxolene Green Resin } ONE HOMOGENOUS MASS

Operating Temperatures:

Continuous	—90° to +250°F
Intermittent, 4 hrs.	—90° to +300°F
Intermittent, 1 hr.	—90° to +400°F

Properties of Luxolene Green Resin:

Tensile strength	10,900 psi
Water absorption	less than 1/10 of 1% after 24 hours immersion.
Thermal coefficient of expansion	6.1×10^{-5}
Thermal conductance	4.9×10^{-4}.
Volume resistivity	megohms CMS 10^{13}
Dielectric strength	400 volts, 1 mil
Arc resistance	85
Dielectric constant	10^{2} cycles 3.90; 10^{10} cycles 2.99
Loss factor	10^{2} cycles .0113; 10^{10} cycles .0252
Solubility	Attacked by concentrated sulphuric acid, but is resistant to concentrated hydrochloric acid. Trichlorethylene, ethylacetate and acetone will attack but not dissolve Luxolene.
Adhesion	Very strong to metal. Makes excellent bond with 105°C Polyvinylchloride lead wires.

LUXOLENE CERTIFICATION
EVERY SHIPMENT COVERED BY THIS CERTIFICATION:

LUXOLENE CERTIFICATION

Serial No. 0000

"We hereby certify that the coils covered by packing slip No..... have been immersed in water at room temperature for 24 hours. After immersion, with 500 volts D.C. applied, the leakage resistance through water to ground has been measured by standard procedures and found to be not less than 200 megohms.

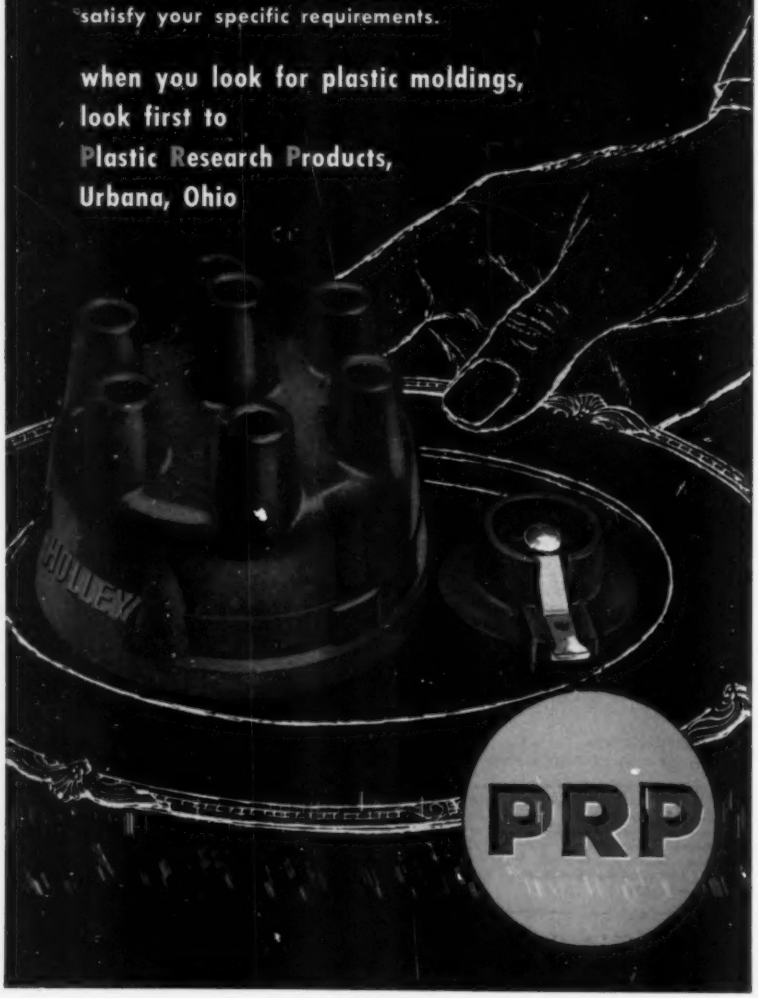
DELUXE COILS, INC., 1306 First St., Wabash Ind.

plaskon alkyd 420 forms another "first" handed to our customers

Highly significant to all industries—doubly so to the automotive industry—are the unique applications of Plaskon Alkyd by PRP which are pictured here. The resulting distributor cap and rotor parts represent the first such use of this talented molding compound in a field long limited to phenolics. Advantages gained by its outstanding dimensional stability and remarkable arc-resistance are self-evident.

Credit Holley Carburetor Company—ever alert for ways to improve product performance and value—for pioneering this newest application of versatile Plaskon Alkyd. PRP mass-produces these pieces on specialized high-speed presses, maintaining extremely close tolerances . . . and exceptionally low costs. Our plane is ready now to speed you here for a review of our facilities and abilities to satisfy your specific requirements.

when you look for plastic moldings, look first to Plastic Research Products, Urbana, Ohio



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The meticulous standards set by Curtis, in selection, heat treating, strength, accuracy, tolerance, concentricity and smoothness, surpass the Class I specifications of the U.S.A.F.

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As a result, Curtis standards — and Curtis Universal Joints — are accepted and used by every branch of the Armed Services.

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Availability — 14 sizes always in stock; bored or unbored hubs. 6" hub diameter joints or special machining to specifications.

Simplicity—fewer parts, simpler construction.

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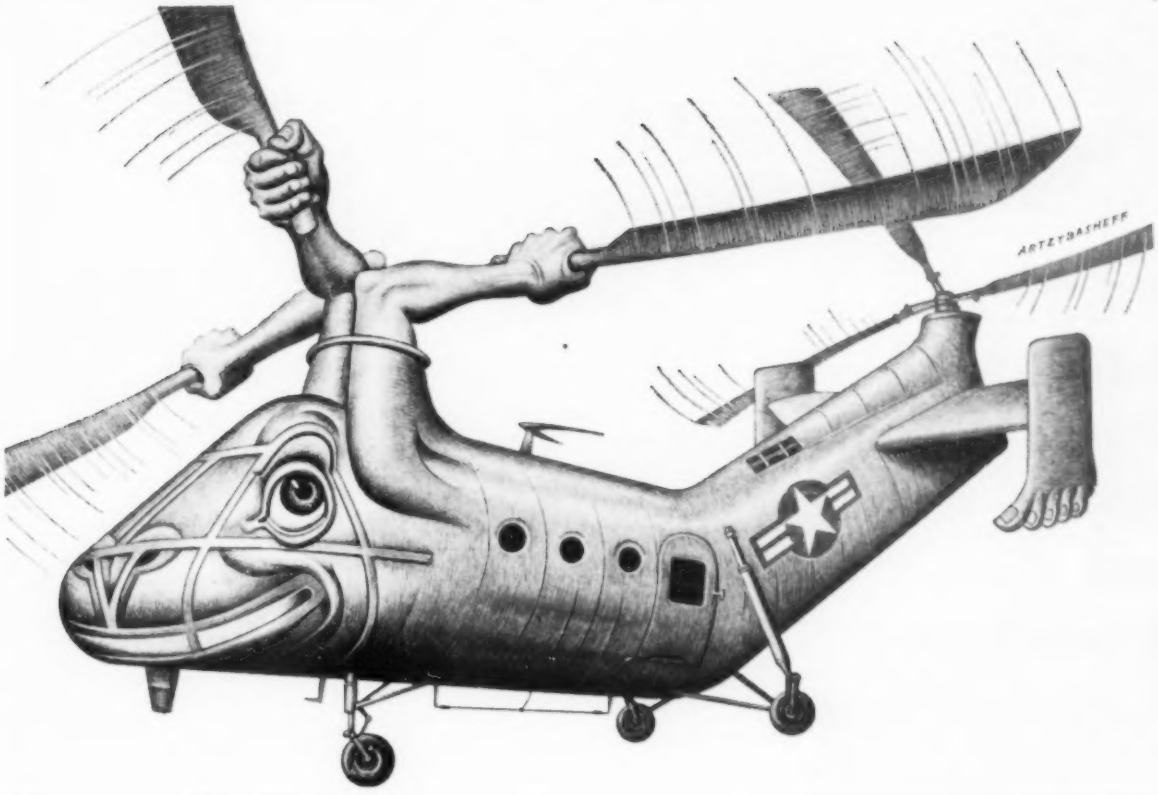

How a helicopter hangs by its "elbows"

Straight up, straight down, forwards, backwards, or just hovering—the Piasecki "Work Horse" Helicopter's peculiar flying maneuverability rests in its rotor assemblies. It is these flexible "elbows" that adjust the pitch of the 'copter's great blades. Each unit involves more than 625 separate parts. To machine and assemble them, Piasecki depends on Lycoming for precision production.

Lycoming stands ready to assist you whether you have a metal product that needs speedy precision or volume fabrication—or "just an idea" in the rough or blueprint stage. Long famous for its metal-working skill, Lycoming continues to meet the most exacting requirements in a wide diversity of fields, both industrial and military. *Whatever* your problem—look to Lycoming!

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For flexible "elbows" —rotor assemblies that control the maneuvers of its H-21 Helicopter—Piasecki looks to Lycoming's precision production

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Please send me further information on Lycoming's varied abilities and facilities.

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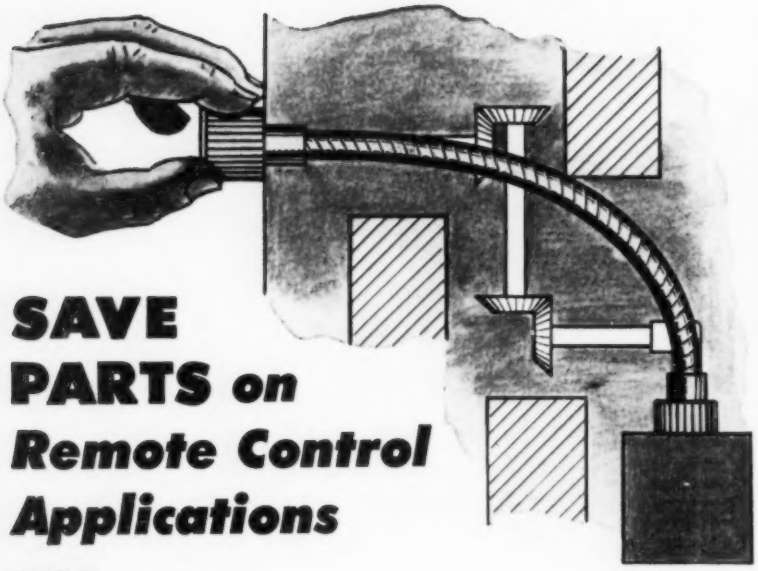

SAVE PARTS on Remote Control Applications use . . . S.S.WHITE FLEXIBLE SHAFTS

Just compare the simplicity of the flexible shaft control shown above, with the combination of rods, bevel gears and bearings that would otherwise have to be used. The savings in parts is obvious. What's more, the flexible shaft is less complicated, needs no alignment, is easier to install and gives you more freedom in mounting the coupled parts where desired to provide better and more convenient operation.

Design simplification and parts reduction are important advantages you gain by using S.S.White flexible shafts on your remote control applications. In fact, these simple, one-piece mechanical elements are just about the simplest, most economical way there is of providing a smooth, responsive control linkage between two parts.

Our engineers will be glad to cooperate with you in selecting and applying flexible shafts to your needs. Take advantage of their help—it entails no obligation and can save you plenty of valuable time and trouble.

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It has full details on flexible shaft selection and application. A copy will be sent if you request it on your business letterhead.

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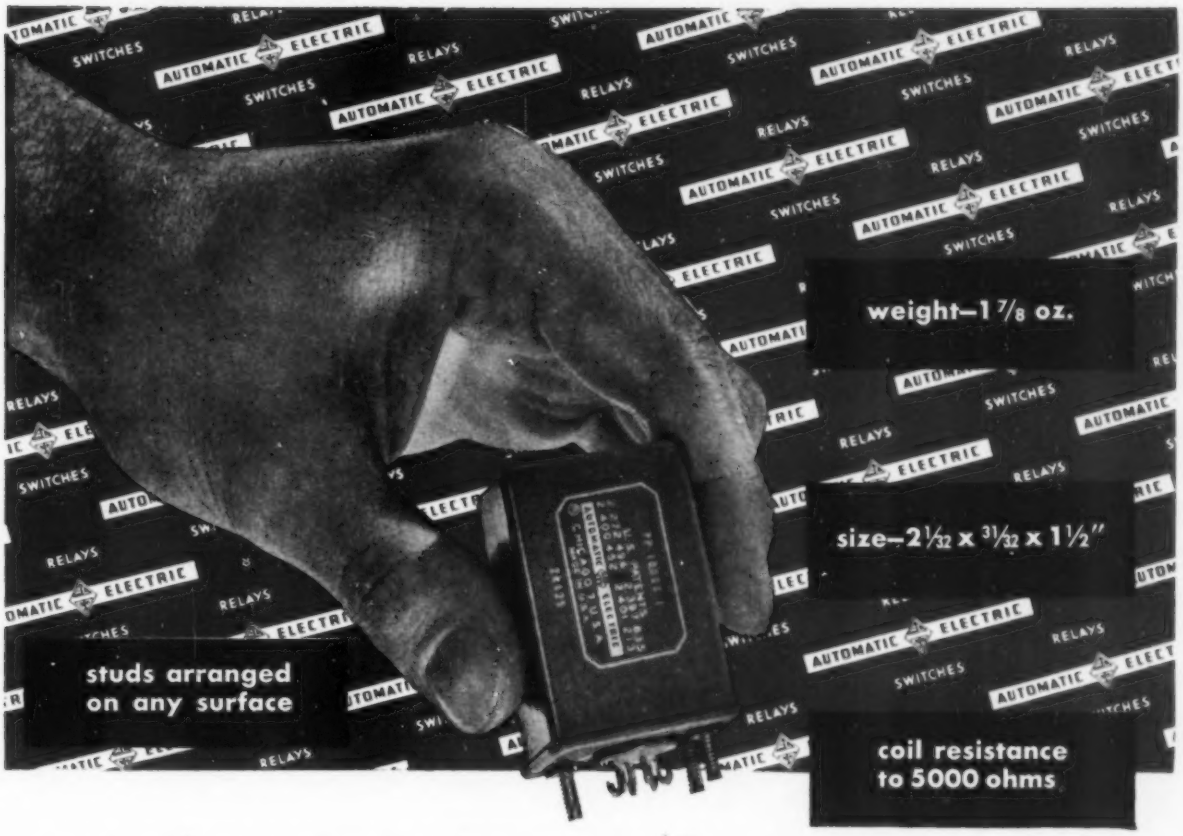
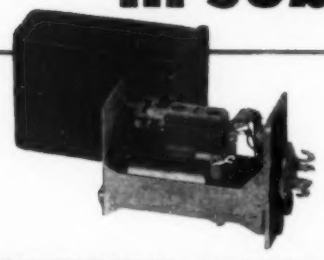


now! relay veteran hermetically sealed
in *sub-miniature* enclosure



AUTOMATIC ELECTRIC sub-miniature relay

- *Developed especially for aircraft service*
- *Designed to meet or better all provisions of MIL-R-6106*
- *Dependable contact operation under vibration up to 10.5 G's*

Specifications

Contact Arrangements—2 Form "C" (DPDT) or equivalent

Operating Voltage—up to 115 volts, d.c. only

Operating Time—range 0.002-0.016 seconds

Release Time—range 0.005-.085 seconds

Contacts—Normally twin, Code 0-20 ga. Will carry up to 135 watts (maximum 2 amperes) inductive or non-inductive load. Makes or breaks 50 watts (maximum ½ ampere) inductive load, or 135 watts (maximum 1 ampere) non-inductive load.

When space, weight and atmospheric conditions are determining factors in relay selection, specify the popular Class "S" relay in this new Automatic Electric sub-miniature hermetic enclosure.

This bantam-sized, feather-weight relay is now available in this new small housing (approximately 3 cu. in.)—hermetically sealed in an inert atmosphere of dry nitrogen. It has proved itself in aircraft and similar applications—and is specified wherever extremes of shock, temperature and vibration require exceptional performance.

If your planning calls for a small, light, atmosphere-protected and tamper-proof relay of recognized ability, minimum inductance and maximum make-and-break speeds —specify this outstanding new member of Automatic Electric's hermetically sealed relay group. For descriptive bulletin, write: Automatic Electric Sales Corporation, 1033 West Van Buren St., Chicago 7, Illinois. In Canada: Automatic Electric (Canada) Ltd., Toronto. Offices in principal cities.

RELAYS SWITCHES

PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF

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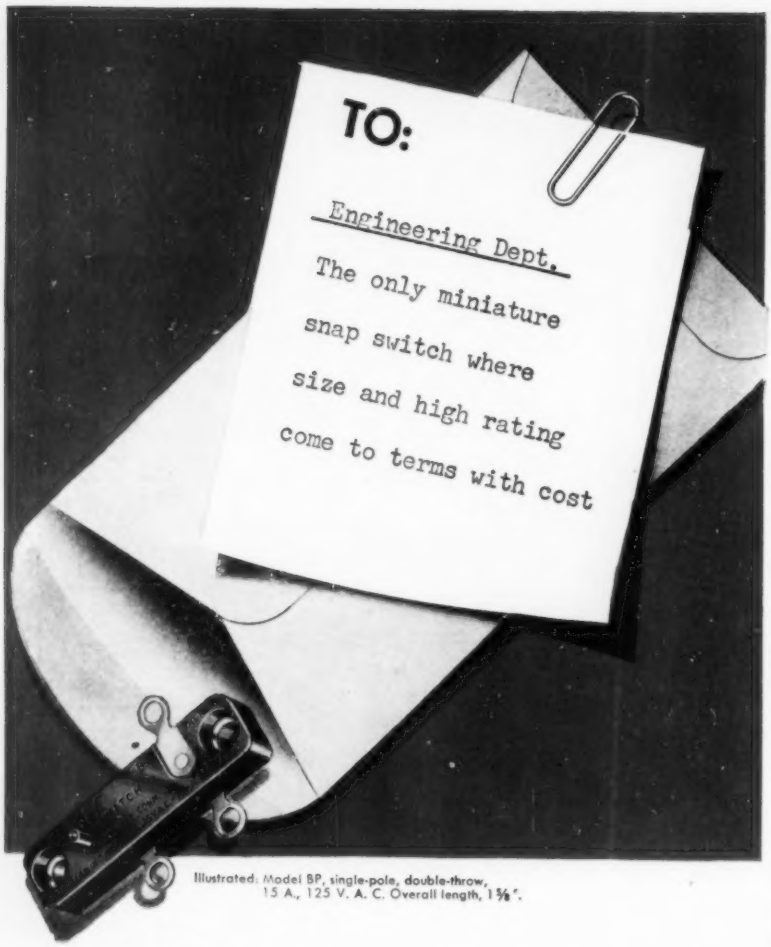

Illustrated: Model BP, single-pole, double-throw, 15 A., 125 V. A. C. Overall length, 1 5/8".

The most practical and economical solution to difficult switching problems ever devised . . . TYNISWITCH.

Like no other snap switch made, this compact, low cost, snap-action unit permits high load switching in a minimum amount of space. It eliminates the need for costly, non-functional bulk in new or redesigned products. Its high force-to-inertia-ratio spring blade inhibits mechanical resonance . . . assures smooth, high-speed operation with positive, bounceless closure. And as for dependability—conclusive laboratory tests have proven that TYNISWITCH is *consistently reliable* at high operating speeds . . . for over millions of cycles!

Consider these important design and production advantages now. New TYNISWITCH models can be developed to fit your exact switching speeds and specifications—or you can select conventional circuit arrangements from a variety of standard units. Write for complete details. TYNISWITCH Division, The Sessions Clock Company, 101 East Main St., Forestville, Conn.

Rout the dollar losses

hiding behind poor cost control

Try the new conversion-cost method of finding and plugging leaks

There is only one realistic way to control cost and thus keep profits from sifting away, says this famous industrial engineer. He brings a thoroughly unique approach to the problem of cost, pricing, and profit in manufacturing. Since manufacturing is conversion of the material to the product, that is the cost that must be reckoned—the total conversion cost. In this book he fully explains the approach and describes the methods through which to plug cost leaks . . . know how to price each line . . . and develop effective methods of cutting costs and increasing production.

Just Published!

HOW TO CONTROL PRODUCTION COSTS

By Phil Carroll

Author of *Timestudy for Cost Control*
Timestudy Fundamentals for Foremen
How to Chart Timestudy Data

264 pages, 6 x 9, 76 illustrations, $5.00

This practical book is written for immediate in-the-plant use. Besides thoroughly explaining the total-conversion-cost method of control, it gives you every tool for putting that method to work immediately.

You start by throwing out old and unreliable systems—budgets that are unrealistic or overhead ratios that are more a drag than a guide.

Then you are shown how to set up the new conversion-cost system, by first setting up a realistic overhead—based on standard time—and finding standard material costs. Thus you can plot your expenses, find your variances, and price your products "right."

The action you must take to make this new system really effective is clearly outlined for you in the book. You'll see here how to make accurate sales forecasts . . . control production within accepted variances . . . get engineers to specify . . . set up effective employee incentives . . . get clear, prompt reports.

Packed with techniques to help you set up the new method:

How to set up **charts for plotting a curve of expenses.** There's only one sound way to do this, says this engineer-manager, and he tells you how to draw the curve, how to adjust the curve, how to read the curve.

How to find your **standard material costs,** and how to figure out the variances from these.

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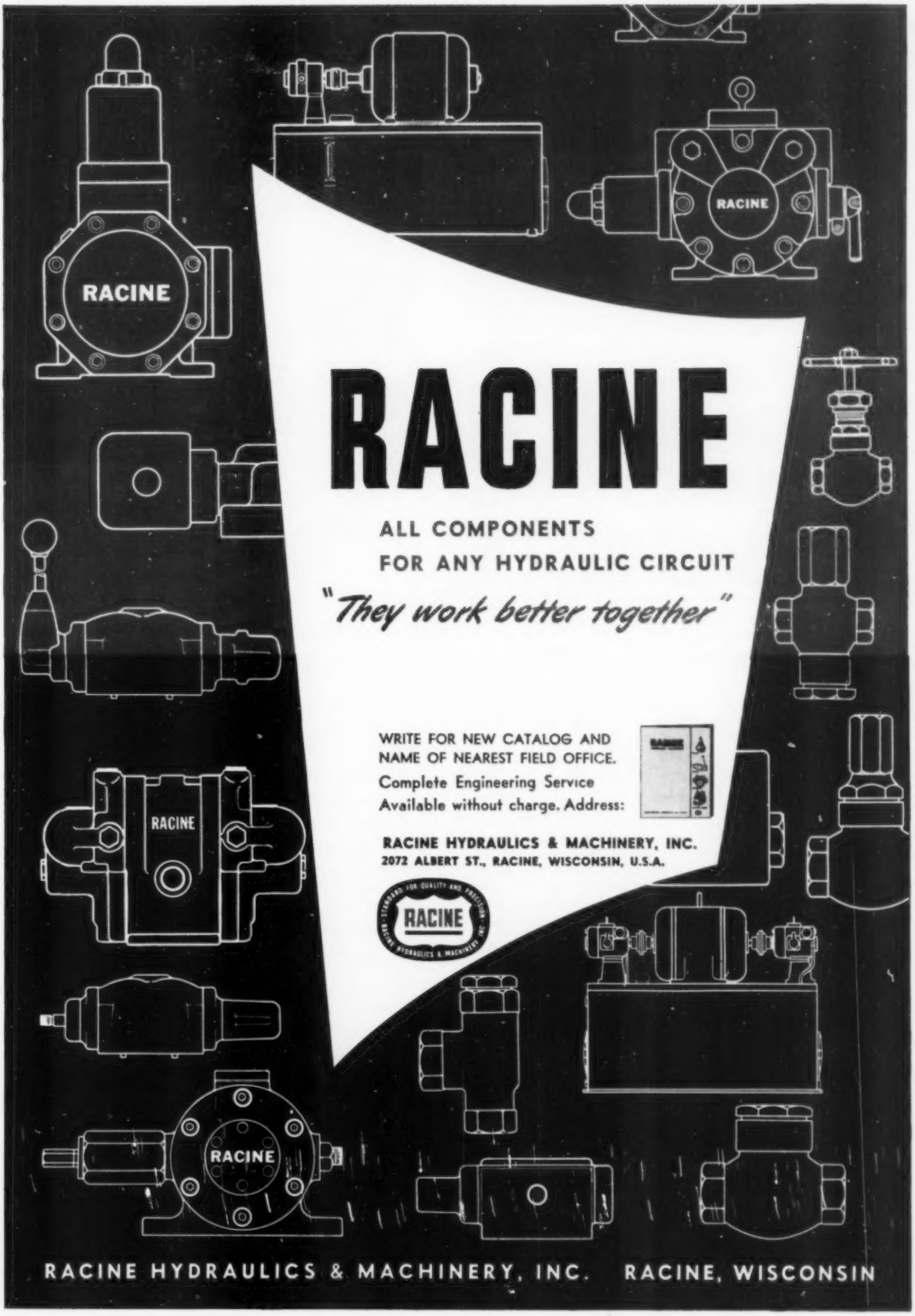
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2 CIRCUIT THERMOSTAT

to control:

Hi-Heat to Low Heat

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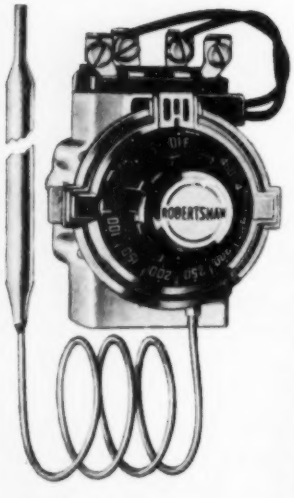

Used to control two heating circuits, or to operate a motor when such operation is required in combination with a heater or commercial laundry dryer, etc. where it shuts off current to heating element and turns on signal light.

When thermostat calls for heat, high heat element automatically cuts in and holds until set temperature is reached. Main contacts are then broken automatically and low, or holding, element is cut in to function until drop in temperature again calls for heat. Maximum temperature range 550°F. Write for full information.

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Single Pole, Double Throw

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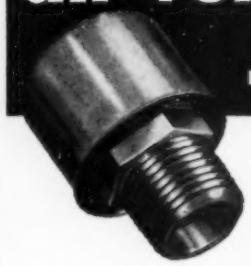

This compact, new ribbon element filter is available *for the first time* in three sizes—¼", ½", ¾" pipe thread, thus meeting the needs of every application.

Positive Controlled Filtration. The specially designed element offers *greater efficiency than any air vent filter* on *the market*—approximately 40 micron filtration (.0016"*)*.

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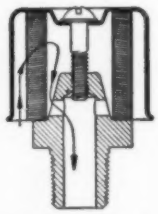
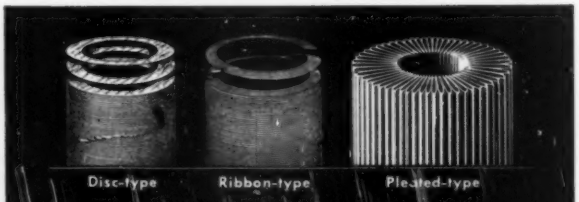


Write Dept. B for complete details on this revolutionary new filter.



Disc-type Ribbon-type Pleated-type

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Are you one of the engineers who have been searching for a bearing metal with higher strength, higher load capacity and resistance to high engine temperatures? Improvements in machine design to reduce unit cost or improve efficiency often require greater loads on the bearings. Now you may design to use sleeve bearings with properties never available before.

These roll-bonded Aluminum-on-Steel Bearings may be used for loads up to 4000 P.S.I., yet have good conformability, good resistance to shaft wear, good resistance to corrosion, adequate seizure resistance and good resistance to fatigue. Tests prove that the bond to the steel back is as strong as the metal itself. These properties make Johnson Aluminum-on-Steel Bearings new high-load, high-speed bearings with a great future for high-load internal combustion engines. Write for full information.

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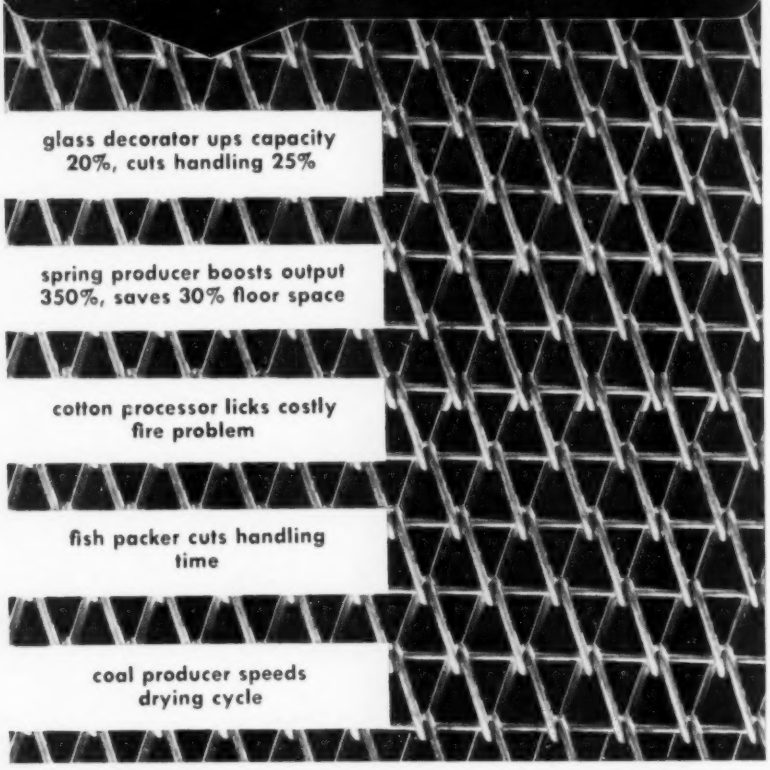
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Cambridge Wire Mesh Conveyor Belts

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They can be used at temperatures ranging from sub-freezing for food packers, to as high as 2100° F. for heat treating. They can be used in corrosive solutions such as pickling acids or in ordinary water if your product must be washed during processing. Open mesh of the belt allows free circulation of process atmospheres, free drainage of process solutions. All-metal construction means long life and low maintenance. They're available in any metal or alloy, mesh or weave, length or width.

Best of all, Cambridge has a solidly experienced Field Engineering staff at your service. Look under "Belting-Mechanical" in your classified telephone book for the man nearest you. Call him in at any time.

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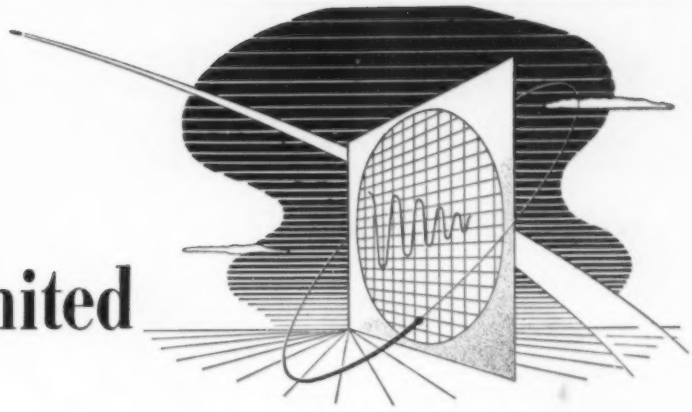

Inhibitions must be stifled if creative development is to have full freedom of expression. Only with a young, imaginative, "of course it can be done" attitude are the great advances of this modern era accomplished.

Ketay

has earned its place among the leaders in precision instrumentation on the record of its virile development and production staffs. Throughout its cumulative years of accomplishment, Ketay has confined its efforts to the development, engineering, and production of new types of electro-mechanical and electronic equipment.

Today, industrial and government orders almost fill the Ketay plants on both coasts. Currently in production is the miniaturized highly precise Ketay Resolver—a type which opens new horizons in automatic control operations. Ketay developments are geared to performance above and beyond present military standards—which, in turn, were set by earlier Ketay product capabilities.

SYNCHROS SERVOS
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DESIGN
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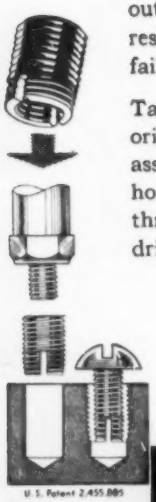
Why TAP-LOK* INSERTS have the edge on other threaded bushings

The cutting edges on the slotted segments of Tap-Lok Inserts make all the difference in the world. They eliminate one time-consuming task — the separate tapping operation. That represents a substantial saving in assembly.

The Tap-Lok Insert is a bushing that is threaded externally to tap its way into a drilled or cored hole equal in size to a tap drill hole that will accommodate the external thread. The Insert is also threaded internally to receive the male threaded member.

The Tap-Lok Insert withstands vibration without loosening and has maximum torque-and-pull resistance. It is not subject to the time-wasting failures of cast and molded inserts.

Tap-Lok Inserts are used in large volume as original equipment on regular production line assembly. In addition, they save many man-hours in salvage work for repairing stripped threads. They are easily inserted with a simple driving tool as shown in the drawings to the left.



U. S. Patent 2,455,885

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GROOV-PIN CORPORATION

1121 Hendricks Causeway **Ridgefield, New Jersey**

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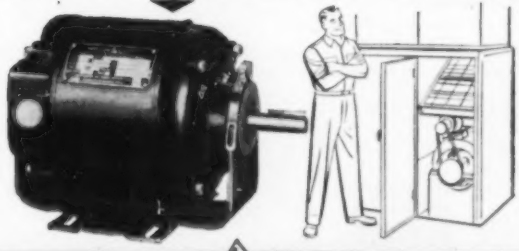

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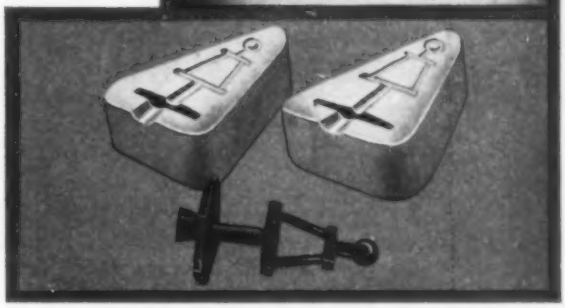

The cold casting compound shown here is made by the Perma-Flex® Mold Co., Columbus 9, Ohio. Thiokol Corporation supplies LP-2 only as a raw material. Because of its desirable properties, "Thiokol" LP-2 was selected as the elastomer for their line of flexible molding pattern compounds.

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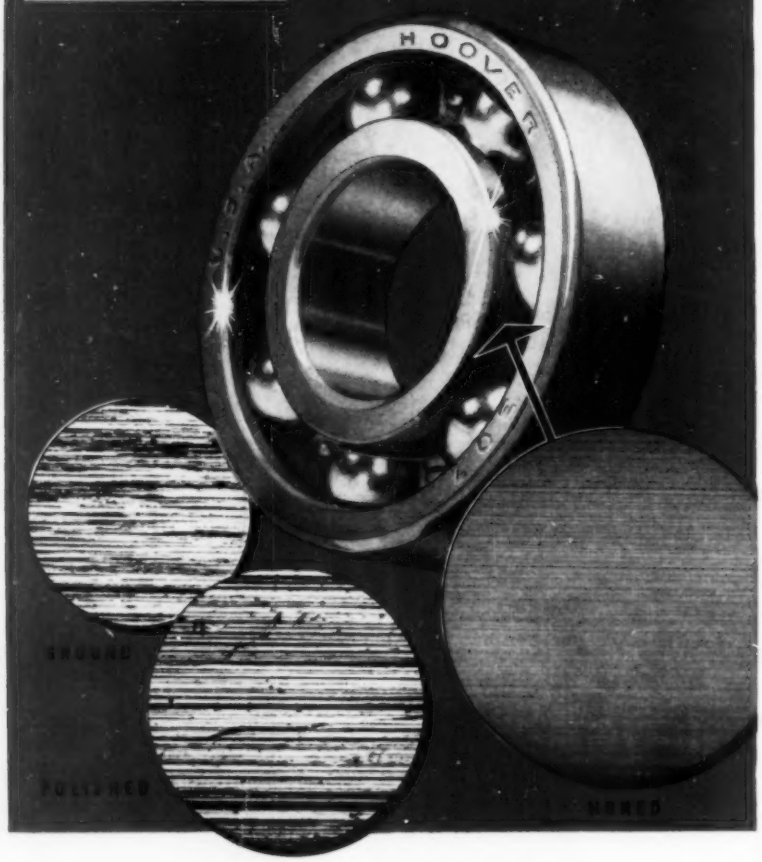

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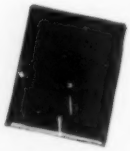

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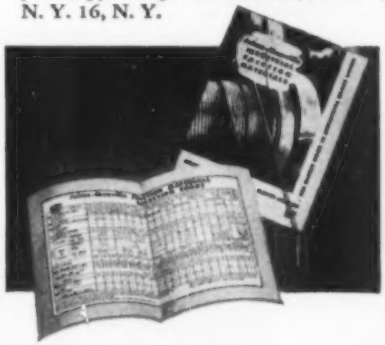
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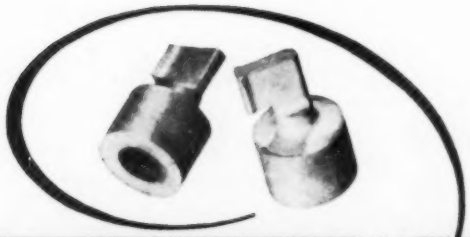
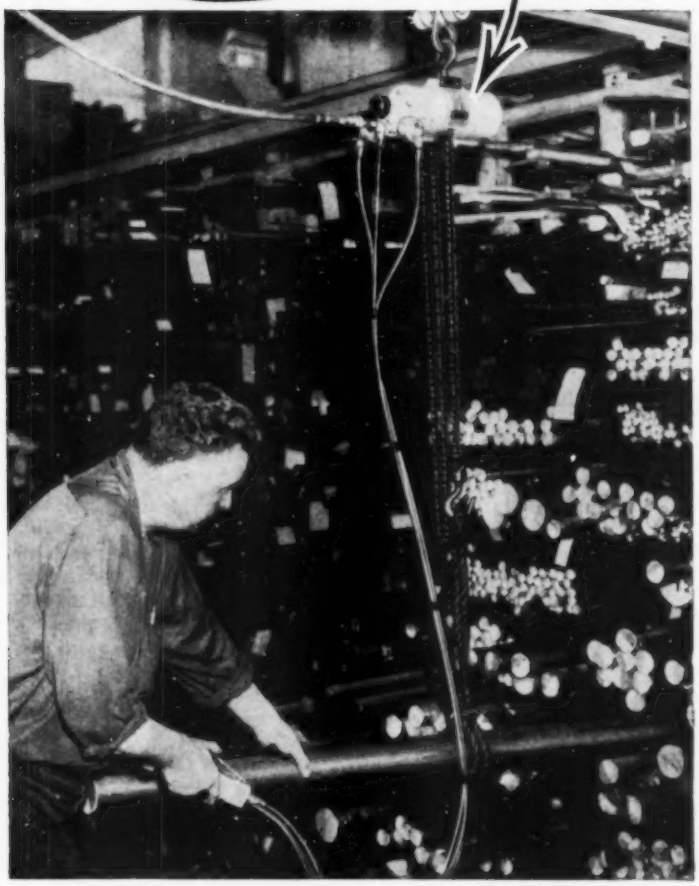


Precision Casting Saves 33%



Control fingers for an air hoist are now precision-cast in one piece. Five machining operations are eliminated.

The control finger for this air hoist is stronger and costs one-third less now that it is a HAYNES precision investment casting. The fingers were formerly machined in two pieces and brazed together. The repeated strain of starting and reversing the hoist caused the parts to break at the brazed joint in two to six weeks. No breakage has occurred since changing over to the investment-cast parts.

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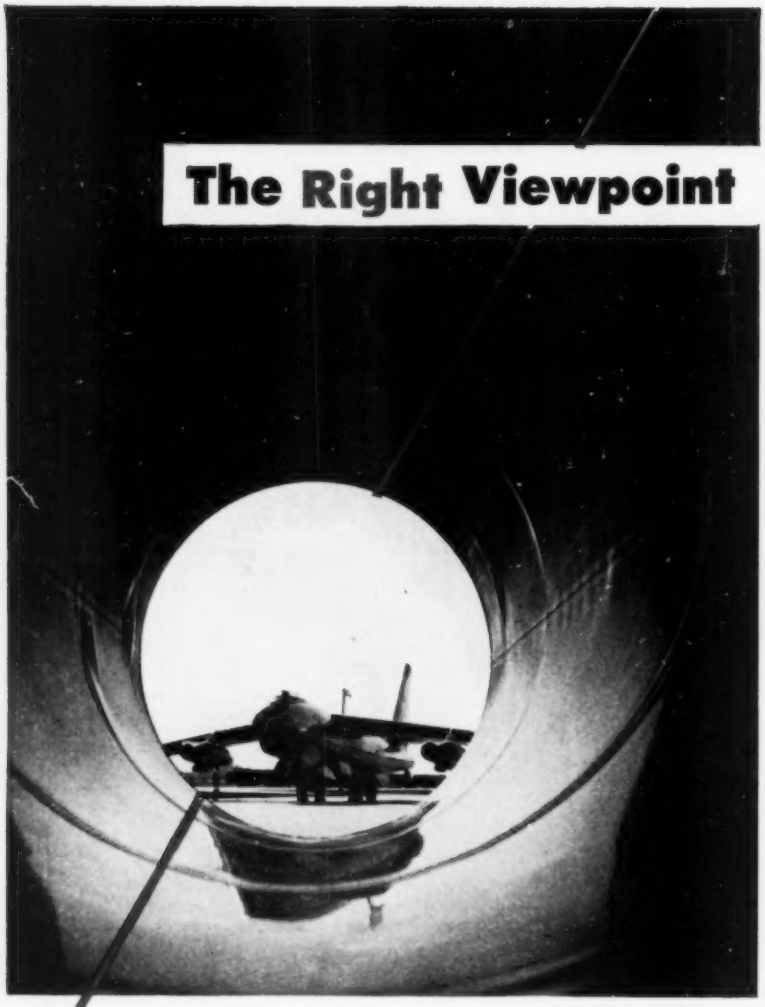

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CONTENTS

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2. Ultrasonic Waves: Further Theory
3. Crystals for Ultrasonic Use
4. Crystal Holders for Ultrasonic Use
5. Resonance and Reflection
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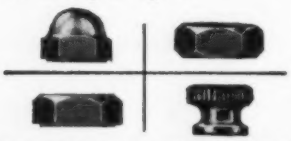

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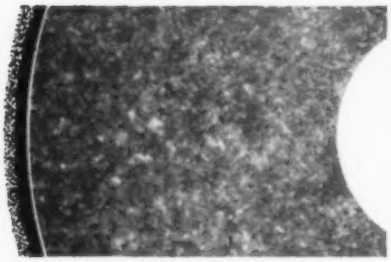
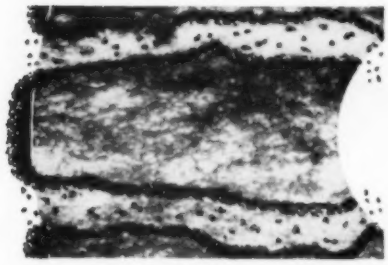
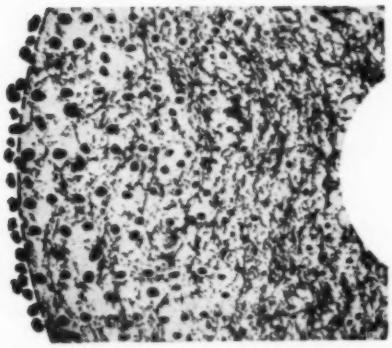


Compare MICRO-KLEAN with FILTERS WITH THE SAME DENSITY THROUGHOUT. The filter media density is the same on the pressure and discharge surfaces of the element; therefore, dirt accumulation is largely on the outside surface, choking the cartridge ("plastering") and reducing the effective filter life.



Compare MICRO-KLEAN with FILTERS WITH HAPHAZARD DISTRIBUTION OF FILTER MEDIA. Uneven haphazard media density permits fluid to find channels through the filter, and pass solids larger than the minimum filter spacing.



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MICRO-KLEAN gives you

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- **longer effective cartridge life**

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Fewer Cartridge Changes Necessary with MICRO-KLEAN Filters

You don't need a complicated, bulky filter to keep dirt and abrasives out of your lube oils, hydraulic fluids and coolants. Cuno's compact MICRO-KLEAN cartridge is all filter, with no space-consuming structural members to offer resistance to flow.

The high porosity and low pressure drop operation of MICRO-KLEAN filters permit full-flow service on gravity, low pressure, or suction lines—with no loss in operating efficiency.

Cartridge replacement costs are generally cut in half when MICRO-KLEANS are used. MICRO-KLEAN's graduated density in depth provides much greater capacity for dirt accumulation within the micronic cartridge, giving twice the useful life of an ordinary filter element. The specially engineered construction of MICRO-KLEAN affords simplicity of installation and maintenance. Changing cartridges can be accomplished in a few seconds—only one nut has to be removed.

Send for Cuno's free filtration analysis form, have one of your engineers fill it out, and mail it to us. We'll let you know exactly what you need for your filtration requirements—without obligation. And take advantage of Cuno's unique "money-back" offer: if MICRO-KLEAN doesn't outperform any filter cartridge you have previously used, we'll send you double your money back. So send the coupon today for free MICRO-KLEAN bulletin. M.3.4

Cuno Engineering Corporation
Dept. 304C South Vine Street, Meriden, Conn.

I'm interested in your "money-back" offer. Please send me your filtration analysis form—and more information on MICRO-KLEAN for

..... (fluid)

Name.....

Company.....

Address.....

City.....Zone....State.....

Winchester Electronics

SOLVES "MINIMUM" WEIGHT AND SPACE PROBLEMS

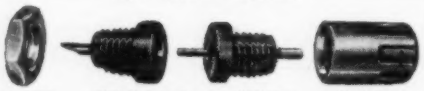
SUB-MINIATURE
Single- and Double-Contact
CONNECTORS

MONOBLOC® CONSTRUCTION eliminates unnecessary creepage paths, moisture and dust pockets and provides stronger molded parts.

MOLDED MELAMINE BODIES (in accordance with MIL-P14a) – mineral filled – are fungus-proof and provide mechanical strength as well as high arc and dielectric resistance.

CONTACTS PRECISION MACHINED: Pins from brass bar (QQ-B611) and Sockets from spring temper phosphor bronze bar (QQ-B746a). They are gold plated over silver for consistent low contact resistance, reduction of corrosion and aid in soldering.

SM1 SINGLE CONTACT



SM2 DOUBLE CONTACT

POLARIZATION: Body design of the "SM2" permits engagement in one position only.

RACK & PANEL MOUNTING: Either plug or receptacle may be panel mounted with a ¼-28 cadmium plated brass nut. A melamine hood protects soldered wires.

SUB-MINIATURE RECTANGULAR CONNECTORS

These connectors also employ standard Winchester Electronics features:

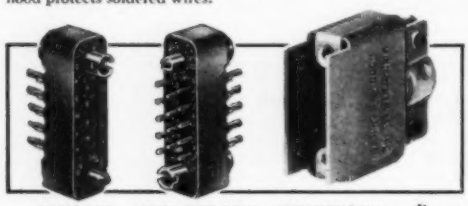
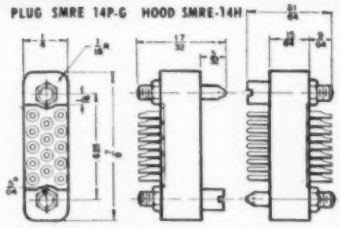


Photo and Drawing of SMRE-14 actual size. Other sizes determined by number of contacts.



STAND-OFF MINIATURE STAND-OFF FEED-THROUGH

Shown here are but a few of the large line of terminals now available and which are particularly useful in limited space applications: 1) As a substantial, well insulated electrical tie point (Stand-off type) and 2) For passing high voltage through a chassis or a panel (Feed-through type).

MOLDED MELAMINE BODY: (MIL-Spec. P-14, Type MTS-G-2 or G-3) for high dielectric and mechanical strength.

TERMINALS: *Solder Type* (Bifurcated or Turret) brass, hot tin dipped; *Screw Thread Type* (Tapped insert or Threaded stud) No. 4-40 or No. 6-32, brass, cadmium plated, clear iridite finish.

MOUNTING METHOD: *Rivet*, hollow aluminum shank (.094" O.D.) assembled by swaging or spinning; *Tapped Insert*, brass, cadmium plated, clear iridite finish, assembled with No. 4-40 or No. 6-32 standard machine screw; *Threaded Stud*, brass, cadmium plated, clear iridite finish, assembled with No. 4-40 or No. 6-32 nut.

BREAKDOWN VOLTAGE:

Stand-off Body Length	D.C. Voltage
7/32"	7,000 V
3/8"	14,000 V
17/32"	22,000 V
19/32"	24,000 V
Feed-through Creepage Length	
5/32"	4,500 V
9/32"	8,000 V

PHYSICAL AND ELECTRICAL DATA

Recept. Code No.	Plug Code No.	No. of Contacts	Solder Cup Dia. In.	Weight Oz.			D.C. Volts Breakdown Connector Engaged			
							Sea Level Normal Humidity		60,000 Ft. Altitude	
				Rec.	Plug	Hood	Between Contacts	Contacts to Gnd.	Between Contacts	Contacts to Gnd.
SM1S	SM1P	1	.043	.02	.04	.02	....	5400	...	1750
SM2S	SM2P	2	.0225	.02	.02	.02	1600	2600	800	1100
SMRE 7S-G	SMRE 7P-G	7	.0225	.1	.1	.1	2450	2050	950	675
SMRE 14S-G	SMRE 14P-G	14	.0225	.2	.2	.1	2450	2050	950	675
SMRE 20S-G	SMRE 20P-G	20	.0225	.2	.2	.2	2450	2050	950	675
SMRE 26S-G	SMRE 26P-G	26	.0225	.2	.2	.2	2450	2050	950	675
SMRE 29S-G	SMRE 29P-G	29	.0225	.2	.2	.2	2450	2050	950	675
SMRE 34S-G	SMRE 34P-G	34	.0225	.2	.2	.2	2450	2050	950	675

If Guide Pins are not desired omit "G" in above Code Numbers.

*Trade Mark
Pats. Pend.

Write for dimensions and other details including terminal types and mounting methods.

West Coast Branch:
1729 WILSHIRE BLVD.
SANTA MONICA, CALIF.

WINCHESTER ELECTRONICS
INCORPORATED

GLENBROOK, CONN., U.S.A.

There's a girl in our office . . .

. . . Whose one job is to expedite delivery of your requests for "New Catalogs and Bulletins" to the manufacturers concerned.

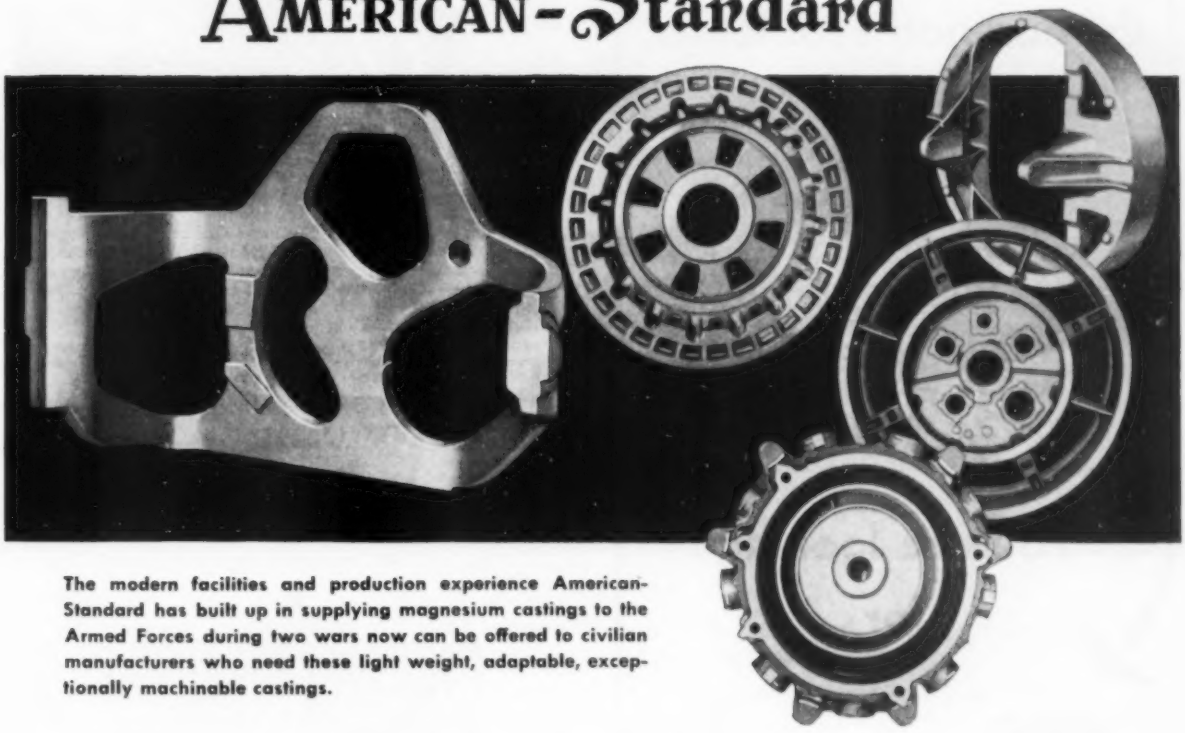
The job keeps her busy, too. She handles several thousand requests from **Product Engineering** readers every month. And she's anxious to be of service to you whenever she can.

So check the "New Catalogs and Bulletins" insert if you haven't already done so. You'll find a lot of useful information listed there . . . and any of it is available to you promptly and without cost.

Product Engineering

NOW...A new source of supply for Magnesium Sand Molded Castings!

AMERICAN-Standard



The modern facilities and production experience American-Standard has built up in supplying magnesium castings to the Armed Forces during two wars now can be offered to civilian manufacturers who need these light weight, adaptable, exceptionally machinable castings.

Although American-Standard is not primarily known for manufacturing magnesium castings, it is not a novice in this field. During World War II and since, American-Standard has turned out these light weight, durable castings for military use. In fact, during the last war when American-Standard had four plants producing these castings, it was the *largest* producer of magnesium sand molded castings.

Now American-Standard can offer to civilian manufacturers some of the output of its Litchfield, Illinois foundry . . . which is equipped with such facilities for control of casting as X-ray, spectrographic analysis, metallographic investigation and other recognized types of foundry controls.

It is equipped to turn out almost any size and shape of magnesium sand molded casting . . . and to serve you promptly.

American-Standard also has experienced engineers who will be glad to analyze your particular design problem, and to help you in any way possible. They're always at your call. For further information about Magnesium Sand Molded Castings, just return the coupon.

American-Standard Products

AMERICAN-Standard

American-Standard
Dept. PE-33, Pittsburgh 30, Pa.
Please send free literature on Magnesium Sand Molded Castings.

Name .....

Company .....

Address .....

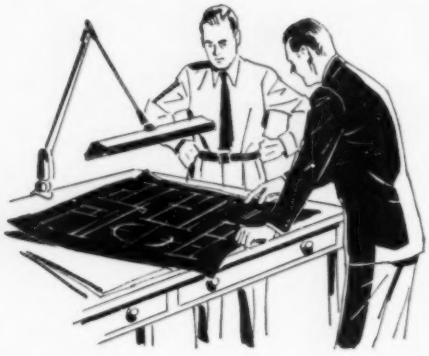
City ..... State .....

American Radiator & Standard Sanitary Corporation, Dept. PE-33, Pittsburgh 30, Pa.

Serving home and industry

AMERICAN-STANDARD • AMERICAN BLOWER • CHURCH SEATS & WALL TILE • DETROIT CONTROLS • KEWANEE BOILERS • ROSS EXCHANGERS

If you are looking for an Answer to a Special Carburetion Problem...



You are looking for

Zenith

Zenith's skill and experience have always been concentrated to one particular end—to provide the finest in specialized carburetion. Through the years Zenith has dealt with every type of engine—ranging from single cylinder lightweights to the most rugged and powerful of gasoline engines—applying 25 years of experience to the mastery of almost every conceivable carburetor problem. In engineering the individual carburetor to the specific requirements of the job, questions of placement, efficiency of performance, and economy of operation are considered from blueprint to production stage. If you are looking for the answer to a particular carburetion problem, you are looking for Zenith. Inquiries will receive prompt attention.

ZENITH CARBURETOR DIVISION OF
696 Hart Avenue
Detroit 14, Michigan
Bendix AVIATION CORPORATION
MANUFACTURERS OF FINE CARBURETORS AND FUEL FILTERS
Export Sales: Bendix International Division, 72 Fifth Avenue, New York, 11, N. Y.

Give you *LEGIBILITY* that *lasts* in metal

Why not let experienced Grammes craftsmen help design the plate that is right for your product? Whether etched, embossed, lithographed or enameled—aluminum, brass or stainless steel—they'll make sure your plate has the right finish for attractiveness and wearability . . . and resists corrosion or deteriorating elements.

PROMPT DESIGN SERVICE Your rough sketch or blueprint will bring prompt recommendations and prices. Meantime write for our new booklet, "Tips on Name Plate Selection and Design."

NAME PLATES DIALS
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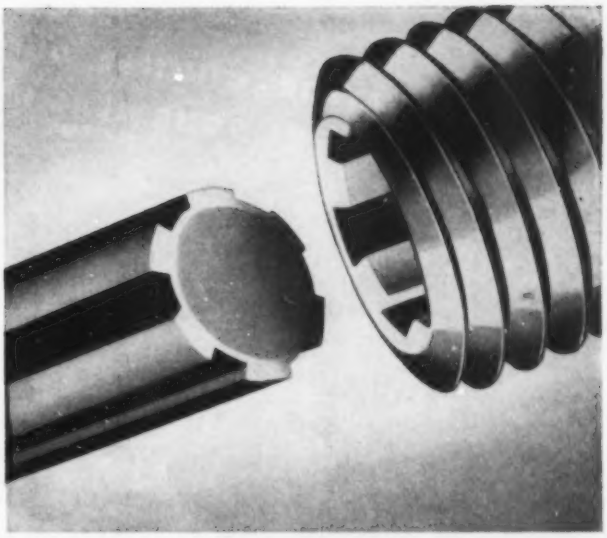
FREMONT, OHIO

BRISTOL'S
Multiple-Spline
SOCKET SCREWS

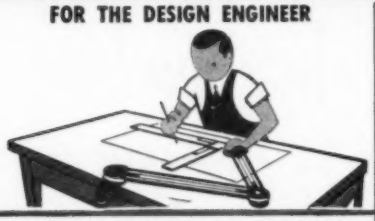
Stronger by far than any other kind!

The splining principle is recognized by design engineers as the best means of transmitting rotary power—that's why it's used in propeller hubs, in drive shafts and rear axles of automobiles. In Bristol's Multiple-Spline socket screws, this design results in strength and holding power not equalled by any other screw.



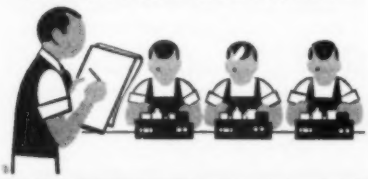
LOOK AT THE THINGS THEY DO . . .

FOR THE DESIGN ENGINEER



- ✔ **Tremendous holding power**
- ✔ **Withstand severe shock and vibration**
- ✔ **Permit neater, more compact design—fit flush, no projecting head**

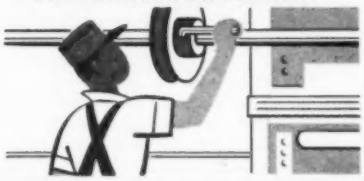
FOR THE PRODUCTION ENGINEER



all the above, *plus* . . .

- ✔ **Greater holding power, permitting use of fewer, smaller screws.**
- ✔ **Will not round out, split or break**
- ✔ **Speed assembly—can be set tighter, easier, faster**
- ✔ **Minimize rejects and marring**

FOR THE MAINTENANCE MAN



all the above, *plus* . . .

- ✔ **Can be tightened and loosened indefinitely**
- ✔ **Maintain desired set—won't shake loose**
- ✔ **Easily wrenched in hard-to-get-at places**
- ✔ **Tamper-proof**

Multiple-Spline Set Screw

Multiple-Spline Cap Screw

Bristol's Multiple-Spline Cap or Set screws are carefully designed to close tolerances (A.S.A. approved, Class 3 fit). Precision-threaded National Coarse or National Fine.

Materials: Standard and listed sizes stocked in heat-treated alloy steel. Brass, bronze, monel, stainless steel, etc., on special order.

Sizes: 0 wire to ½ in. in diameter.

FOR 30 YEARS A BRISTOL EXCLUSIVE!

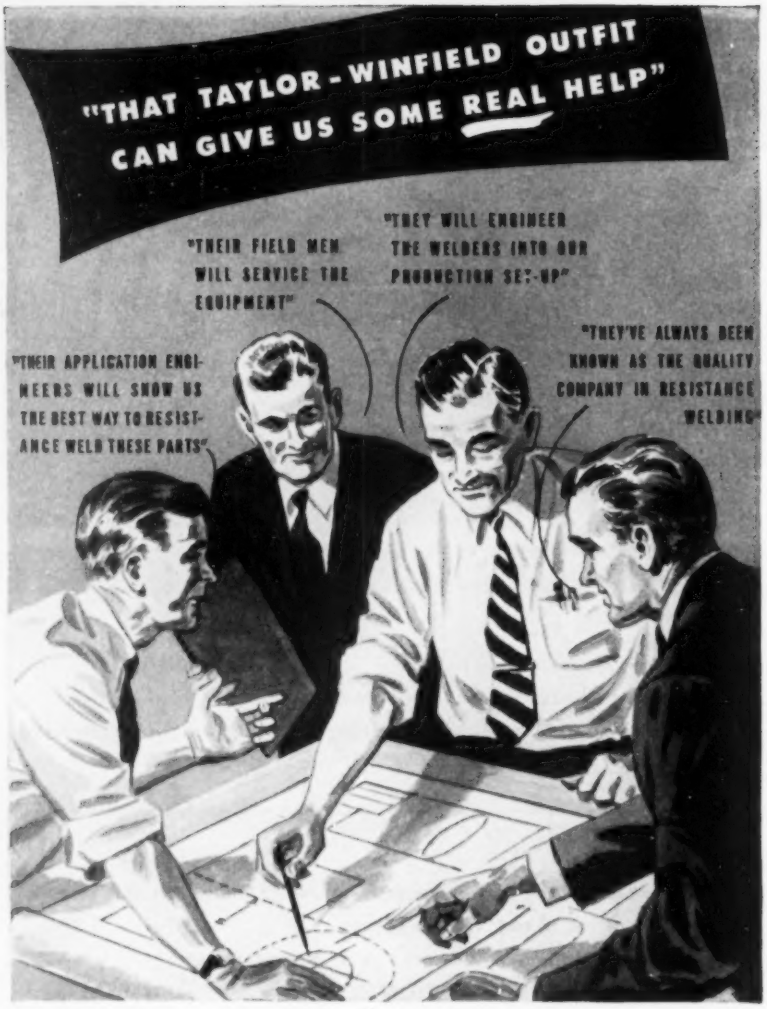
Write for free bulletins showing applications. Only Bristol makes *both* Multiple-Spline and Hex . . . for severe and regular service.

BRISTOL'S SOCKET SCREWS

Multiple-Spline and Hex Socket Screws. Cap and Set

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Connecticut

A.3.1


"THAT TAYLOR-WINFIELD OUTFIT CAN GIVE US SOME REAL HELP"
"THEIR FIELD MEN WILL SERVICE THE EQUIPMENT"
"THEY WILL ENGINEER THE WELDERS INTO OUR PRODUCTION SET-UP"
"THEIR APPLICATION ENGINEERS WILL SHOW US THE BEST WAY TO RESISTANCE WELD THESE PARTS"
"THEY'VE ALWAYS BEEN KNOWN AS THE QUALITY COMPANY IN RESISTANCE WELDING"

IF YOU HAVE a production **joining** problem, bank on resistance welding and use the facilities of Taylor-Winfield. We have sales and application engineers who spend their time on specific customer projects.

If you will outline your needs, we will give you some practical help. T-W specializes in shirt-sleeve assistance on resistance welding. We design, engineer and build resistance welders into your production line. For prompt attention, address your inquiry to the nearest sales office.

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TAYLOR-WINFIELD
RESISTANCE WELDERS

Resistance Welders Since 1898

THE TAYLOR-WINFIELD CORPORATION • WARREN, OHIO

he's working for you

THIS FELLOW IS TRAINED IN YOUR BUSINESS. His main duty is to travel the country — and world — penetrating the plants, laboratories and management councils . . . reporting back to you every significant innovation in technology, selling tactics, management strategy. He functions as your all-seeing, all-hearing, all-reporting business communications system.

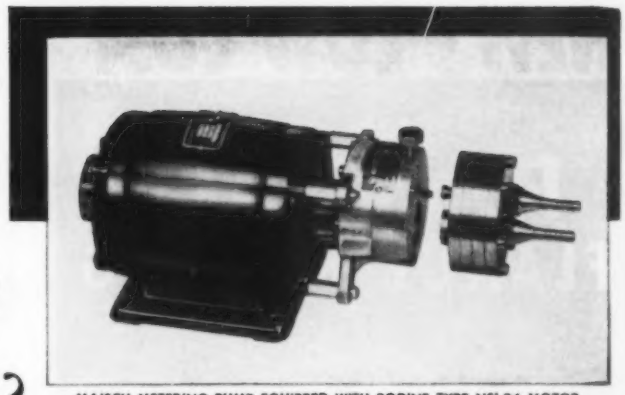
THE MAN WE MEAN IS A COMPOSITE of the editorial staff of this magazine. For, obviously, no one individual could ever accomplish such a vast business news job. It's the result of many qualified men of diversified and specialized talents.

AND, THERE'S ANOTHER SIDE TO THIS "COMPOSITE MAN," another complete news service which complements the editorial section of this magazine — the advertising pages. It's been said that in a business publication the editorial pages tell "how they do it" — "they" being all the industry's front line of innovators and improvers—and the advertising pages tell "with what." Each issue unfolds an industrial exposition before you — giving a ready panorama of up-to-date tools, materials, equipment.

SUCH A "MAN" IS ON YOUR PAYROLL. Be sure to "listen" regularly and carefully to the practical business information he gathers.

McGRAW-HILL PUBLICATIONS

Is your product's motor a sales asset?



MAISCH METERING PUMP EQUIPPED WITH BODINE TYPE NSI-34 MOTOR

To properly dispense, in measured volumes, such hard to pump liquids as, for example, luminescent chemicals for television tubes, heavy chocolate syrup, concentrated orange juice, sterile compounds, biological fluids and whole blood was a difficult, time-consuming task before the advent of the Maisch Metering Pump. One of the reasons for the success of the Maisch Pump is its quality construction, consisting of stainless steel gears operating in a pure carbon and stainless steel housing, with precision lapped plates providing air-tight, metal-to-metal seals.

Maisch Pumps, with all their fine construction features, are no better than the motor providing the necessary power. If the motor fails, the unit becomes useless until repaired. The same holds true for your product. And if the motor fails on your product, your customer will blame you, not the motor manufacturer. Many other manufacturers, like Mechanical Products, also find that Bodine's reputation for quality motors, built up over nearly half a century, adds to the saleability of their products.

Oliver Maisch, President of the Mechanical Products Corporation of Chicago, states that—

"To insure the maintenance of our pumping efficiency, Bodine motors were selected as a dependable source of uniform power. Your motors are standard equipment for our units because of their established trade acceptance, based on years of proven efficient and economical performance. The sturdy, compact, construction of Bodine motors also added materially to the eye appeal of our completed assemblies."

You may want to equip your product with a Bodine motor because our wide variety of standard motors—over 3500 in all types and ratings (1/2000 to 1/6 HP)—will hold the number of cost-increasing modifications to a minimum. There are many reasons, but they all come back to the fact that Bodine gives you more for your motor dollar. If you have a motor application problem, it will pay you to consult Bodine engineers.

THE POWER BEHIND
THE LEADING PRODUCTS

Bodine Electric Co., 2260 W. Ohio St., Chicago 12, Ill.

REPRESENTATIVES IN PRINCIPAL CITIES
IN CANADA: RENOLD-COVENTRY, LTD.

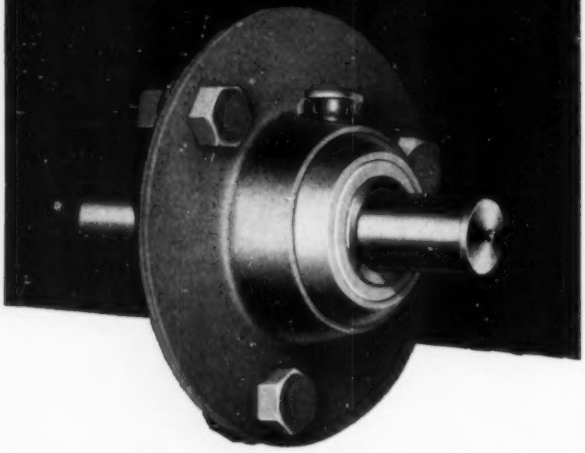
bodine

FRACTIONAL HORSEPOWER MOTORS

BODINE

NEW—LOW COST

RANDALL FLANGE BEARING



SPECIALLY DESIGNED for LIGHTWEIGHT FABRICATIONS

Compact and light in weight, this new, low cost, flange sleeve bearing unit is easy to install. Fast assembly—true alignment of shaft in all directions — self lubrication — low cost maintenance and extra long bearing life, are just a few of its many outstanding advantages.

Ideal applications are Grain Machinery—Conveyors — Packaging Machinery — Air Moving Equipment and Agricultural Implements.

This new unit is available with sintered bushings for normal duty or with patented Randall Graphited Bronze bushings for heavy duty applications. Shaft sizes available are $\frac{1}{2}$"—$\frac{5}{8}$"—$\frac{3}{4}$"—$\frac{15}{16}$" and 1". Special pre-packed, sealed for life, bearings are also available for operating temperatures from —10°F to +140°F.

Ask your distributor for more information on this new bearing assembly today, or write direct to our office.

SEE OUR CATALOG IN SWEET'S STEEL

BRONZE BAR STOCK
BRONZE BUSHINGS
PILLOW BLOCKS
SHEET LUBRICATOR

Randall

GRAPHITED BEARINGS
THRUST WASHERS
BRONZE CASTING
SAFETY COLLARS

RANDALL GRAPHITE BEARINGS, INC.

1004 S. GREENLAWN AVE., LIMA, OHIO

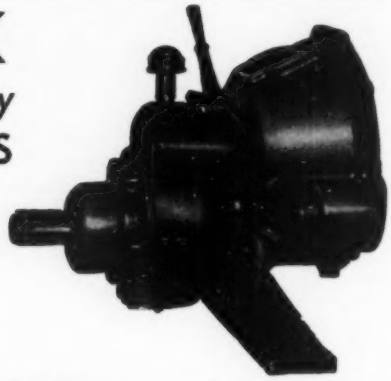
Imperial

THE *Finest* TRACING CLOTH

Imperial is known in drafting rooms all over the world as the traditional quality tracing cloth.

With the background of decades of experience, its makers have pioneered in modern improvements to maintain Imperial as the finest tracing cloth made.

FUNK *Heavy-Duty* CLUTCHES *and* POWER UNIT DRIVES



FUNK Power Take-Offs are available in a wide variety of types to fit most requirements for shaft speed and installation space. Designed to fit any Ford Industrial Engine or standard SAE flywheel housing. *Above* is heavy duty clutch and gear reduction unit. Write for specifications, or for assistance on any special power problem.

FUNK Products include:

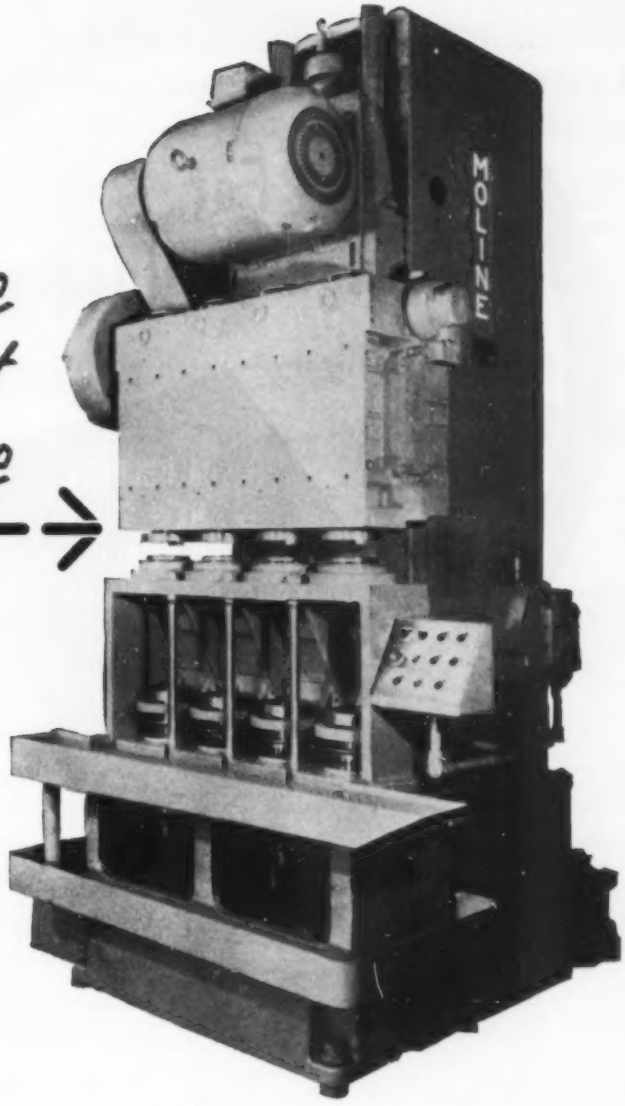
- Straight Power take-off clutches
- Gear reduction take-offs
- Right angle take-offs
- Front end take-offs
- Jack shaft extensions
- Ford Tractor Conversion Kit changes to 6 or V-8 engine, doubles power.

FUNK AIRCRAFT CO.

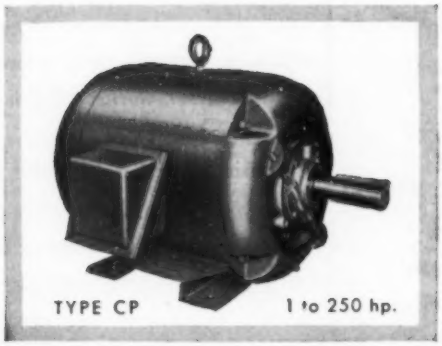
3301 Airport Drive Coffeyville, Kansas

Wagner
ELECTRIC MOTORS
... the choice of leaders in industry

This boring machine is protected against excessive downtime



...it's equipped with Wagner Motors



This hydraulic rail feed cylinder boring machine, with four spindle heads, bores and counterbores 4.2" steel mortar shells. The main motor drive is a 40 hp. Wagner totally-enclosed fan-cooled motor, and the hydraulic feed pump is powered by a 3 hp. Wagner motor.

Machine tools powered with Wagner totally-enclosed fan-cooled motors (type CP) are assured freedom from excessive downtime caused by motor failure, because these motors are fully protected against damage from steel filings, chips, dust, dirt, fumes and moisture.

For your requirements, there is a Wagner Motor to fit every need—a complete line for all current specifications, with a wide variety of enclosure types and mountings. Bulletin MU-185 gives full information. Do you have a copy?

A nearby Wagner engineer will be glad to help you select the *right* motors for your next application. Consult the nearest of our 32 branch offices, or write us.

Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
6406 Plymouth Ave., St. Louis 14, Mo., U.S.A.

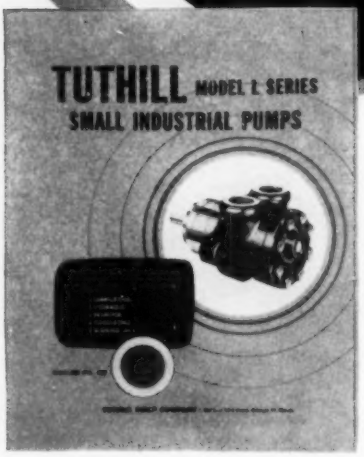
ELECTRIC MOTORS · TRANSFORMERS · INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS – AIR AND HYDRAULIC

BRANCHES IN 32 PRINCIPAL CITIES

M53-7

For Design Engineers

A HELPFUL NEW GUIDE TO SMALL INDUSTRIAL PUMPS



This new Tuthill Catalog No. 101 on the Model L series of pumps presents the information you need for incorporating these dependable pumps into your equipment. It includes a special Pump Guide on Model L applications, plus complete specifications and performance data. Write for your copy of Catalog No. 101 today.

Tuthill Model L Pumps are designed for LUBRICATING, HYDRAULIC, TRANSFER, CIRCULATING and BURNING OILS SERVICE.

TUTHILL PUMPS FOR THE PURPOSE

TUTHILL PUMP COMPANY
Dependable Pumps since 1927
939 East 95th Street, Chicago 19, Ill.

HOW TO PLAN PRODUCT COLORS

8 pages—20 cents a copy

Howard Ketcham, well-known industrial designer, has developed color and design themes for over 500 products and packaged items ranging from household appliances to locomotives. In this *Product Engineering* report he discusses the principal factors involved in matching color with product function, sales and advertising appeal, maintenance considerations, worker efficiency, safety, and size effect.

Copies of other reports in *Product Engineering's* series of full-color articles covering product improvement through better surface appearance and protection are also available. Write for an editorial reprint order form, listing titles and costs.

READER SERVICE DEPARTMENT

Product Engineering

McGraw-Hill Building,
New York 36, N. Y.

Do you hesitate to use ELECTRONIC CONTROLS in your product because of the problem: "What happens when the controls cease to function?"

Now—RELIABILITY IN SERVICE for your Electronic Controls through Alden Components for Plug-in Unit Construction

A whole new CONCEPT

ALDEN PLUG-IN UNIT CONSTRUCTION

—giving these vital advantages:

1) If Electronic Controls fail, your customer is able to restore operation in 30 seconds by plugging in replacement spare.

2) Visual signals tell instantly what needs replacement or adjustment.

3) Non-technical personnel can accomplish restoration of service.

4) Individual units are compact enough to be airmailed to you for servicing.

These design standards are absolutely vital to any manufacturer planning to incorporate electronic circuitry into his equipment, and expect to send that equipment out into shops, offices and all sorts of distant locations and have it reliable in operation. Electronic controls are wonderful when working smoothly. When they go awry, it's usually some minor flaw, the tiniest thing . . . but can be a headache . . . unless you provide for easy finding and fixing, by designing to Alden Plug-in Unit Standards; using—

The COMPONENTS to make it work!

We have spent four years evolving the design principles of Alden Plug-in Unit Construction and have perfected a completely integrated line of components to mount, circuitize, house, fasten, monitor and connect all types of electronic devices, from simple recorder to giant computer. These components are already tooled and in production. No procurement headaches—prompt delivery—sometimes from stock.

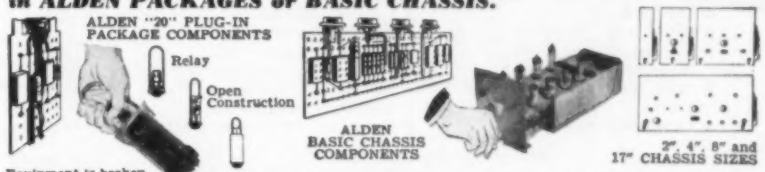
How Reliability in Service is built into your controls

Your circuitry is unitized in compact vertical planes using ALDEN TERMINAL CARD MOUNTING SYSTEM.

PREPUNCHED TERMINAL MTG. CARD + MINIATURE TERMINALS + JUMPER STRIP Eliminates wiring for common circuits + CARD-MTG. SOCKETS = YOUR COMPLETED CIRCUITS

You can use Alden Terminal Mounting Card with Alden Miniature Terminals, Jumper Strip and Sockets staked to accommodate any circuitry—making complete units ready for housing. Components snap into unique Alden Terminals, are held ready for soldering.

Your circuits become easily replaceable plug-in units by mounting in ALDEN PACKAGES or BASIC CHASSIS.



Equipment is broken down into easily replaceable plug-in units

Alden components provide standard plug-in or slide-in housings —with spares, your circuits become units replaceable in 30 seconds.

Color-coding quickly identifies replacement units — non-interchangeability of connectors positively prevents mis-matings.

Choice of variable pin patterns guarantees against mis-mating
Socket to match Base pattern
ALDEN UNIT CABLE
Variety of connectors assures plugging in only where intended.

Your plug-in units are monitored with ALDEN SENSING ELEMENTS that spot trouble instantly.

MINI-TEST POINT for instant voltage checks
"PAN-I-LITE" Miniature Indicator Light
"FUSE-LITE" INDICATING FUSEHOLDER Fuse blows—lite glows

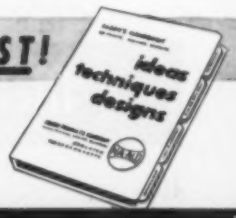
ALDEN SLIDE-IN BACK CONNECTORS give central color-coded check point of incoming and outgoing circuits, eliminate blind massing in block connectors.

To be practical, Electronic Controls MUST be designed and built for RELIABILITY IN SERVICE. Alden Design Standards, Alden Components are the answer.

To design for RELIABILITY IN SERVICE, this Handbook is a MUST!

Here are 226 pages unfolding in comprehensive detail the plug-in unit principles to assure RELIABILITY-IN-SERVICE in any electronic device. Complete specs of all the related components are included. With this Handbook an engineer can readily design any electronic device or circuitry to include the vital advantages of plug-in unit construction.

SEND FOR YOUR FREE COPY TODAY



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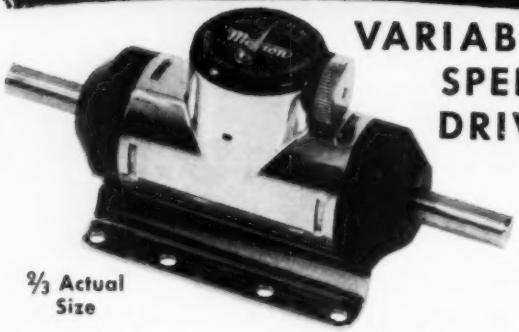
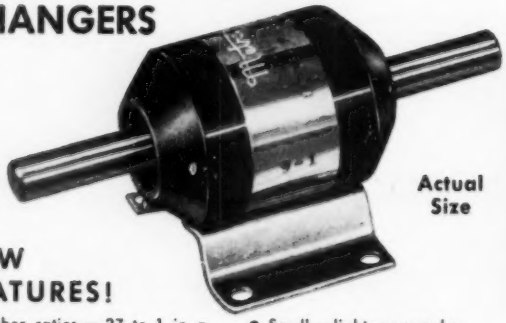


⅔ Actual Size

- They're small
- Weigh only 5½ ounces
- Continuously variable speed range
- Knob, lever, push-rod, or gear control
- Completely sealed unit
- Coaxial shafts for in-line construction
- Permanently lubricated
- Ball-bearings throughout
- Rotation in either direction
- Operates in any position
- Prompt deliveries on all types

Write for Bulletin 99

GEAR TYPE SPEED CHANGERS



Actual Size

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- Mount in any position
- Single section weighs only 3 ounces
- Prompt deliveries on all types

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For applications requiring variable speed at a reduced nominal output speed, combinations of Metron Variable Speed Drives and Speed Changers are available in compact, integral units. Ask for Bulletin 100, or write giving your requirements for prompt engineering recommendations and prices.

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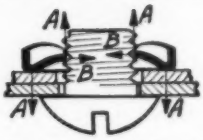

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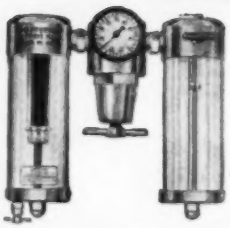

The value of "M-B" Automatic Air Line Filters, Regulators and Lubricators is widely known for their effectiveness as a protection to Air Valves, Cylinders, Pneumatic Tools, etc.

"Your 'Sentinel of the Air Line' has been giving us very good service. We have had no complaints at all and I trust that we will be ordering more of them in the near future."

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4. Make millions *more* precision pieces a year than you could with hi-carbon, hi-chrome dies!

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For additional information send for **FREE** *bulletin # 1400A.*

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New York 36, N. Y.

Precision casting news

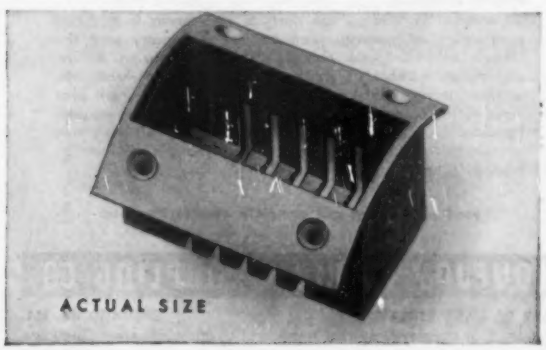
by Arwood Engineers

The spectacular "Casting of the Month" illustrated here is an aluminum Waveguide Energy Absorber produced for radar equipment.

It has important features that will be interesting to Design Engineers. For instance, the rectangular cavity is cast to exact size with no draft permissible. Then, too, the slots in the rectangular section of the casting and the countersunk holes on the cylindrical flange require no machining after casting. Finally, the maximum wall thickness allowable is .060 and the curved flange tapers to a sharp edge at each end.

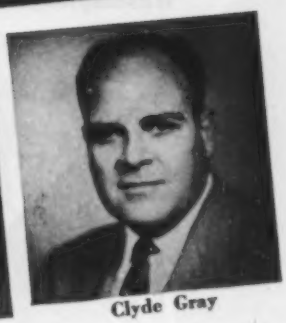
Aluminum is but one metal that Arwood casts. Others are copper, bronze, brass, magnesium and various steels. Details are in our booklet, "A Critical Survey of Investment Castings."

TIP TO DESIGN ENGINEERS—When an Arwood Casting can save 75% on material and labor costs, it's something to think about. That's what happened with the casting shown which was formerly machined from bar stock. And it often happens when Product Design Engineers work closely with our engineers to develop parts.



from Arwood

Ernest White



Clyde Gray

These are the men who represent Arwood so competently in Southern California. Both Ernest White and Clyde Gray have many years of practical shop experience. Their first hand "know-how" of the foundry business makes them able to give sound and valuable advice to manufacturers. Designers and engineers will be particularly interested in their story of how well and how economically Arwood Precision Castings can do a difficult job.

Both Ernest White and Clyde Gray invite you to visit them, Booth 268, Western Metal Congress, Los Angeles, March 23-27.

For more complete information write for our booklet, "Alloy Selection and Design for Investment Castings."

☆ ☆ ☆

An important new book—"Investment Casting for Engineers"—has just been published by Reinhold Publishing Co., New York. It is highly recommended reading for all design engineers.

ARWOOD

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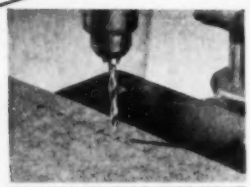
hardboard
for men with designing ideas



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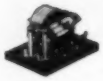

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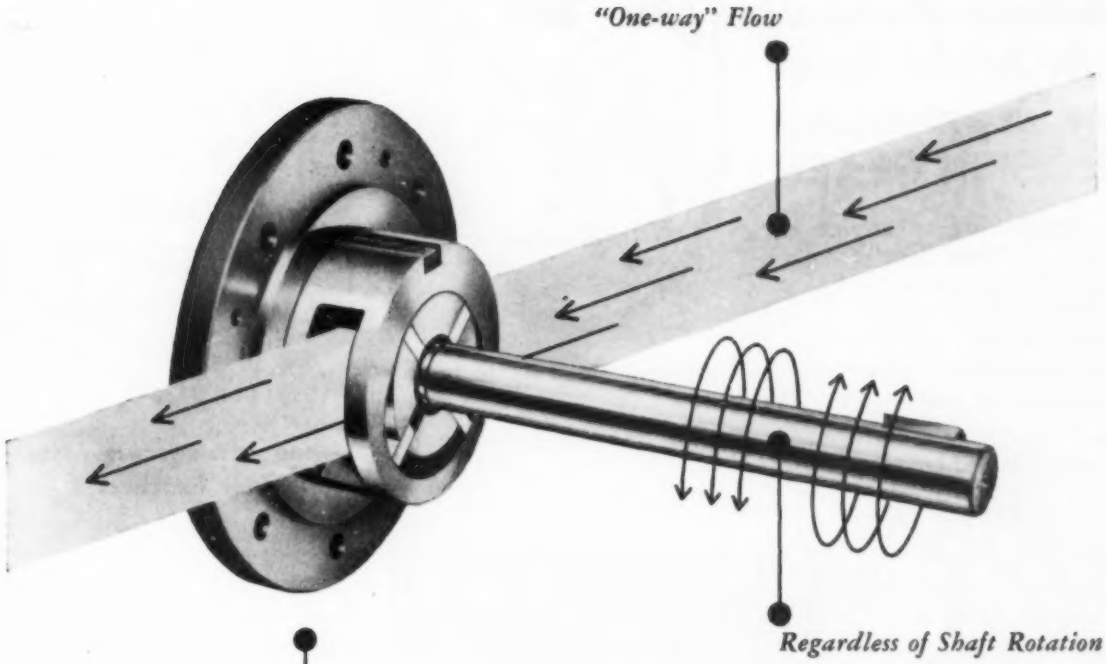

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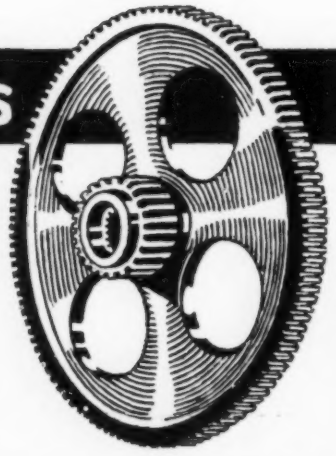

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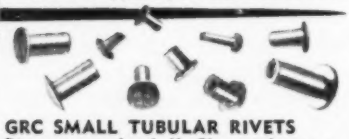

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This book provides a blueprint that shows how you can win executive success. Showing that executive genius is not a quality one is born with, but the result of concentrated effort along the right lines, the book tells how to direct the same efforts and thinking which you already expend daily toward the definite goal of improving your executive ability. Packed with helpful pointers it tells how the up-and-coming executive can make the most of his capabilities, grow in executive stature, and rapidly qualify for the upper bracket responsibilities and rewards.

Some facts this book gives you:

- how to plan advancement
- the secret of executive personality
- 3 best methods for improving personality
- 11 ways to put over your personality
- 24 guideposts to productive thinking
- 11 aids for making decisions
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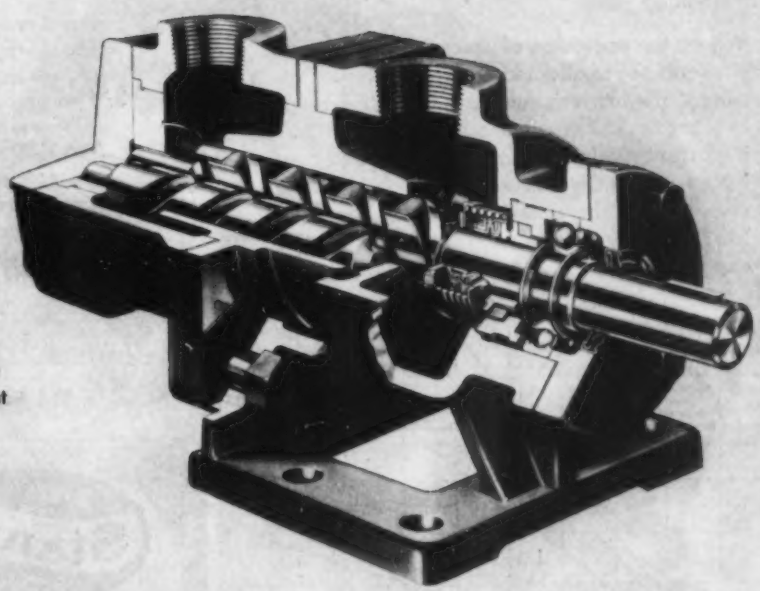
Profit by his sound, versatile experience. He can aid you in selecting the IMO Pump you need . . . give you facts and figures on performance . . . bring valuable judgment to bear on your specific fluid handling application.



For example, De Laval-IMO Series A313B Pump handles light or viscous fluids in hydraulic systems, rotary and steam atomizing oil burners, lubrication, governing systems and similar services. Use it for capacities to 80 gpm, pressures to 275 psi and intermittent pressures to 325 psi.

IMO Rotary Pumps have only 3 moving parts. There is nothing to get out of order, nothing to adjust. IMO Pumps are also easy to install. They can be direct-connected to electric motors, turbines or other high speed drivers, without reduction gearing, belts or chains.

Rotors are in hydraulic and dynamic balance. That means pulsation free operation—no churning, no pocketing, no intermittent strokes. The natural smooth rolling action of IMO rotors eliminates noise, vibration and hydraulic whine.

Models can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 1,500 psig. *Ask for Bulletin LG-A which gives data in chart form on the wide range IMO line.*

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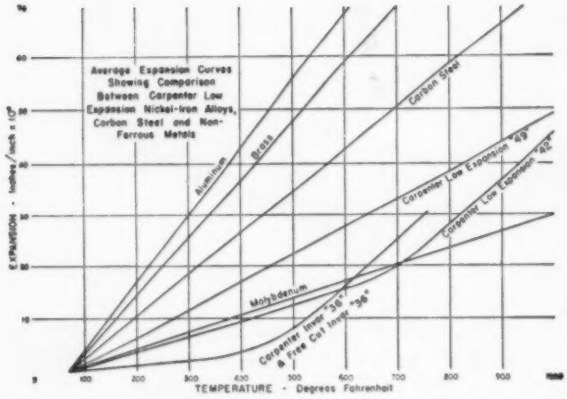
DL187

An alloy with practically no thermal expansion up to 400°F

Note in the graph how the low thermal expansion rate of Carpenter Invar "36" compares with other metals. The free-machining alloy, Carpenter Free-Cut Invar "36", has the same low expansion characteristics and simplifies production of machined parts.

Where the operation of precision instruments or machines is affected by temperature variations, the low expansion of this alloy helps to insure constant accuracy. Another important use is in automatic on-and-off controls, such as thermostats. These controls are operated by the difference between invar's low expansion rate and that of a high expansion metal.


Average Expansion Curves Showing Comparison Between Carpenter Low Expansion Nickel-Iron Alloys, Carbon Steel and Non-Ferrous Metals
Aluminum
Brass
Carbon Steel
Carpenter Low Expansion "49"
Carpenter Low Expansion "42"
Molybdenum
Carpenter Invar "36"
Carpenter Free Cut Invar "36"
EXPANSION - Inches/inch x 10⁶
TEMPERATURE - Degrees Fahrenheit

For detailed engineering data on the Carpenter Invar "36" alloys, write for a copy of the Carpenter Low Expansion Alloy book. It contains 23 pages of data on expansion and mechanical properties, physical constants, etc.

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Please send a copy of your Low Expansion Alloy Book.

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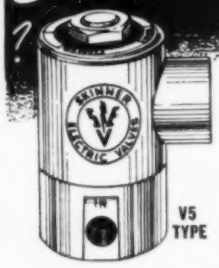
Solenoid Valve Problem?



A Standard Skinner may fill the bill!

Standard V5 Skinner stainless steel solenoid valves, either 2 or 3 way, are available with dozens of options to meet special needs for control of liquid or gaseous media. Such options include *by-pass, metering, manual override, various electrical connections and port locations, manual reset, etc.* Standard valves from 5 to 250 p.s.i.—specials from 5 to 1500 p.s.i. Power consumption, 10 watts max. Soft insert seats prevent leakage, and spring loading assures positive action. Large capacity, yet only 2¾" high x 1⅜" dia. Send your standard or special requirements to Skinner—write for Bulletin 501 for complete details.

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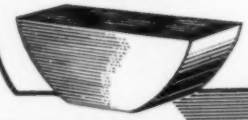

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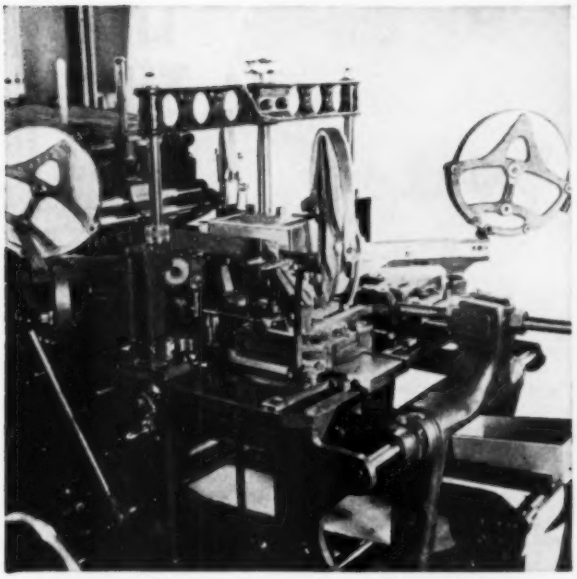
Mighty Midget THERMOSWITCH® Unit bosses temperature in tight spots



1. THE HEAT'S ON in this box making machine — heat-sealing box corners. Speed of boxes passing through determines desired temperature. Four Fenwal Midget THERMOSWITCH units control the four heaters precisely — yet must do their work in very tiny space. Only Fenwal Midgets could do it!

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4. FOR FREE BULLETIN on Fenwal Midget THERMOSWITCH units just write. It gives detailed information and engineering specifications on this new versatile THERMOSWITCH unit for use in confined spaces. Fenwal engineers are glad to assist on your application problems. **Write Fenwal, Incorporated, 23 Pleasant St., Ashland, Mass.**

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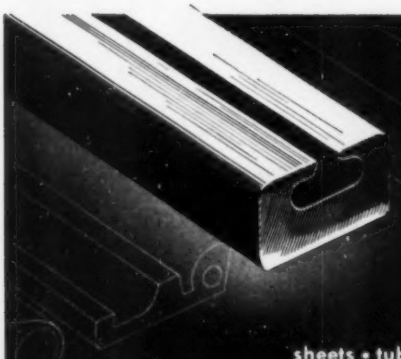

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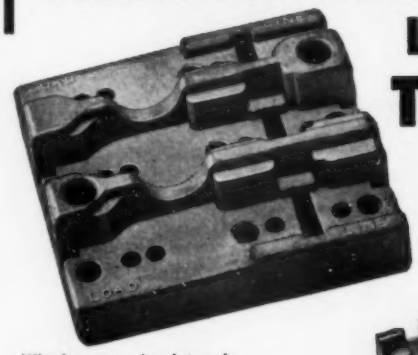

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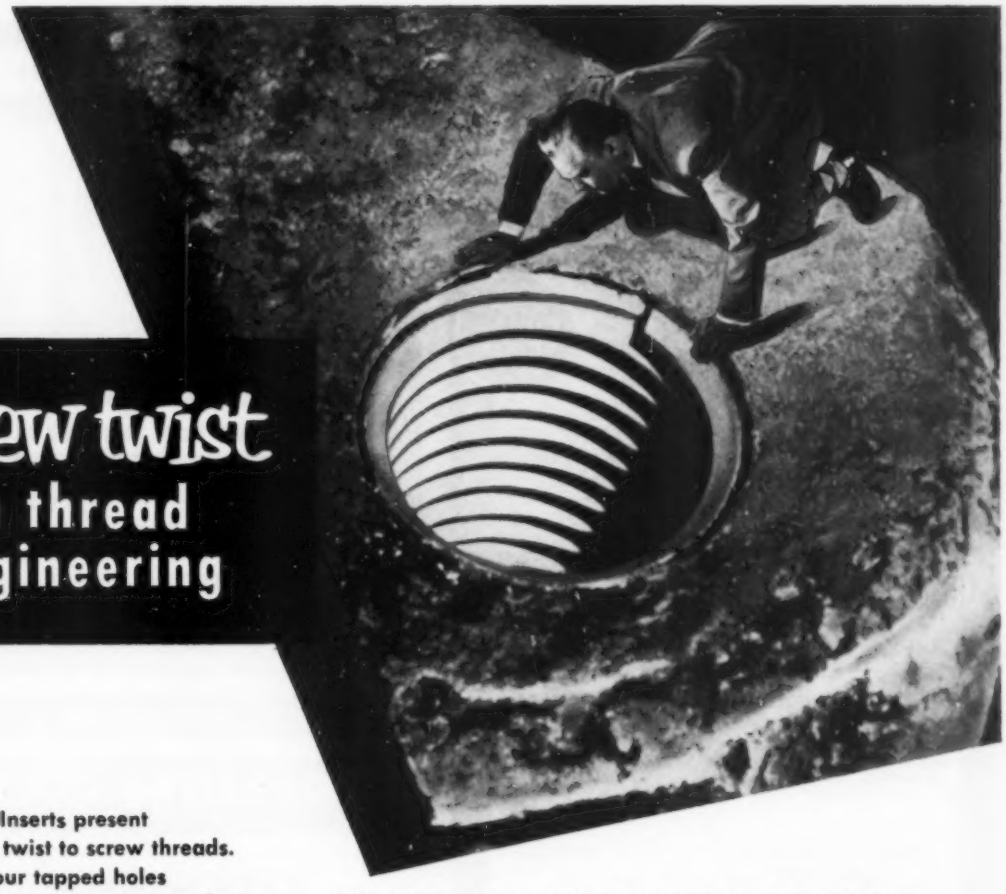

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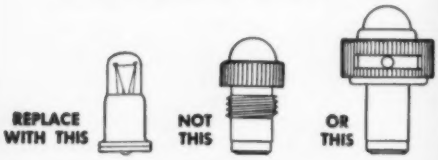

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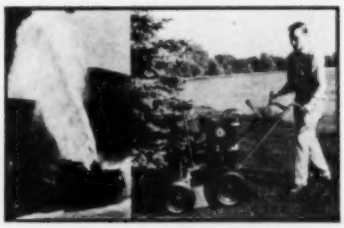

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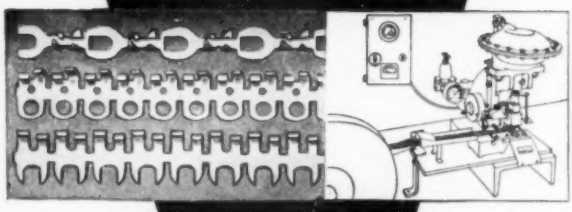

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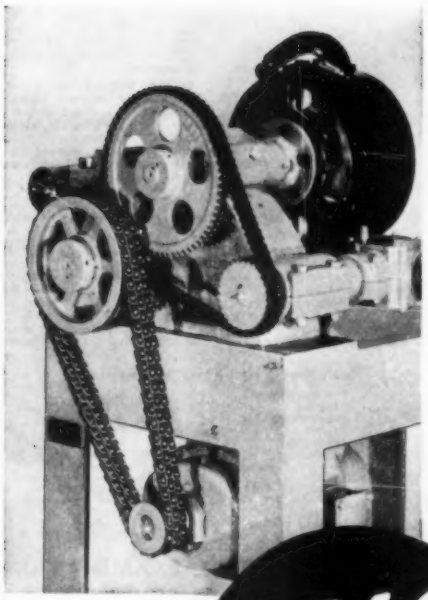

THAT'S a fair question for you to ask any manufacturer—and it's a question the Veelos sales engineer wants to answer. Basically the facts are these . . .

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VEELOS
THE LINK
V-BELT

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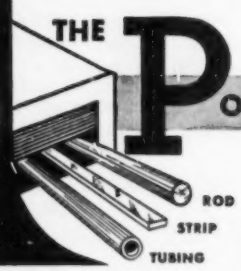

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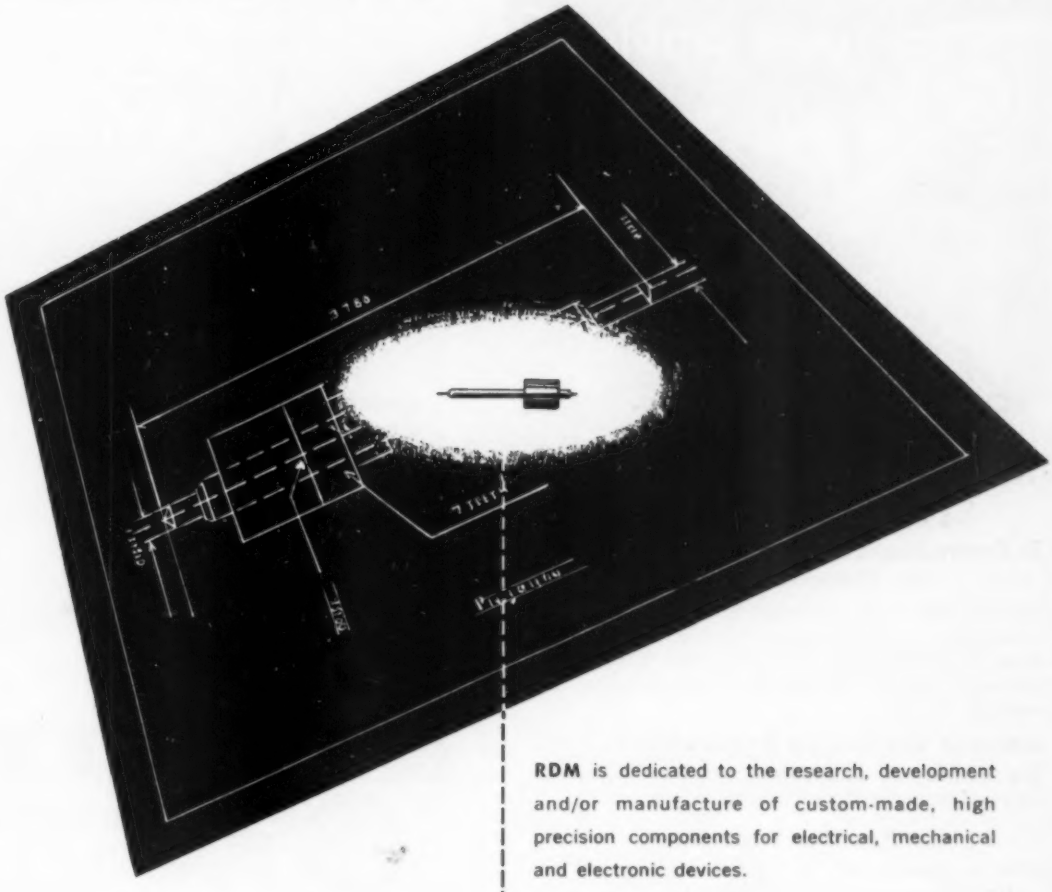

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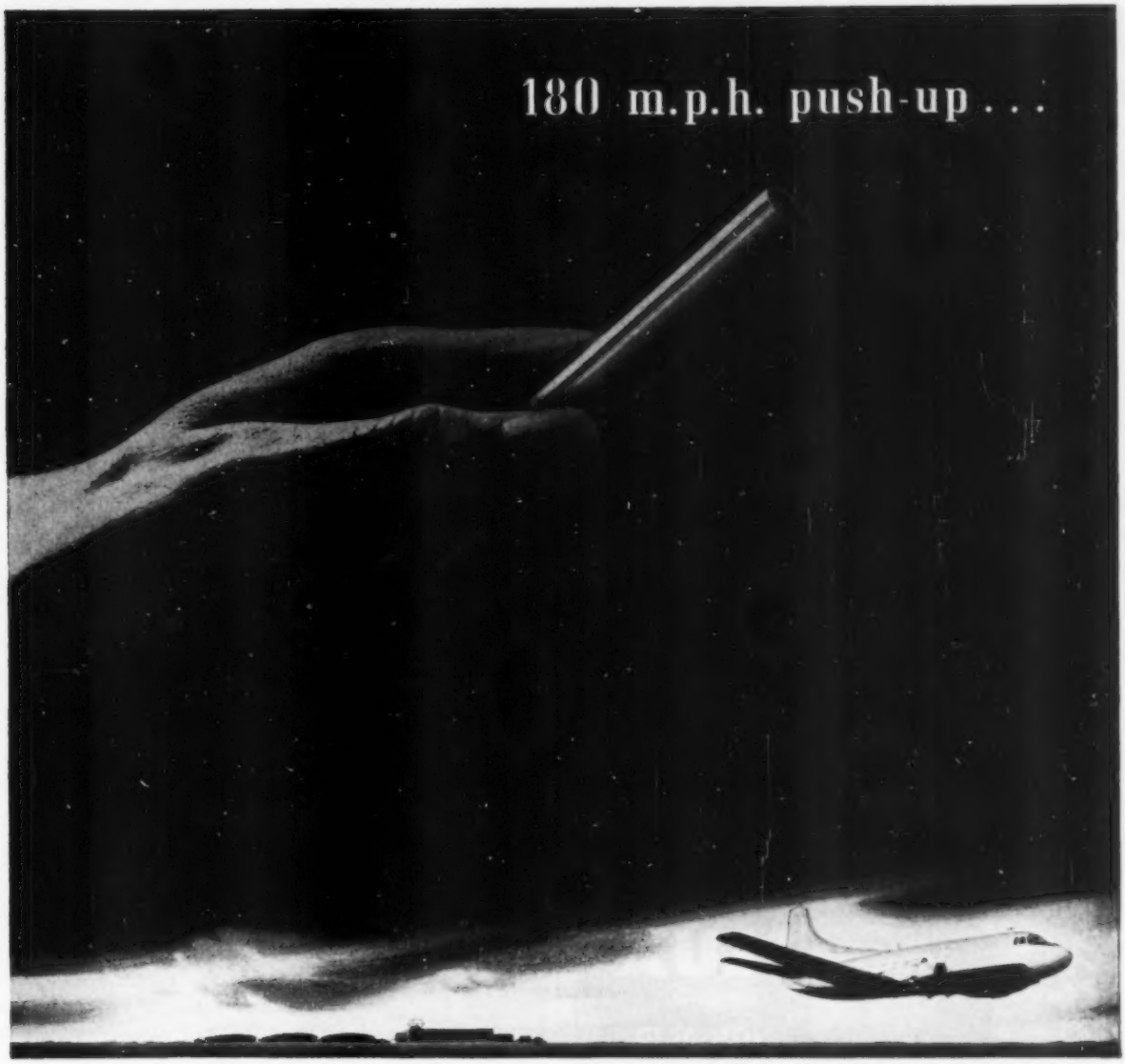

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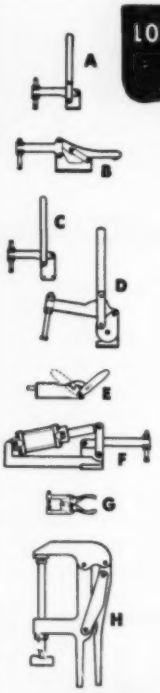

LOOKING FOR AN EFFICIENT CLAMP?

- of the right design
- the right size
- the right pressure

Look to *KNU-VISE*

for the right answer to your clamping problems

A with vertical handle
B with horizontal handle
C with side mount
D with swivel positioning
E push and pull type
F air-operated
G pliers
H C clamps

Sales offices in principal cities. Teletype DE-49

KNU-VISE PRODUCTS **LAPEER MFG. CO.**
3058 DAVISON ROAD • LAPEER, MICHIGAN
Western Division: 422 Magnolia St., Glendale, Calif.

"He Might Need It..."

"He never was much for letter-writing when he was in college. But he must know how anxious Mother and I are . . . now that he's off in Korea. Haven't heard from him in six weeks. Of course, they say 'no news is good news' . . . but I wonder. Maybe he can't write . . . because . . . maybe he's in a hospital somewhere. And maybe he needs blood. I don't know . . . but I'm not taking any chances. That's why *I'm* giving blood."

★ ★ ★

Yes, all kinds of people give blood —for all kinds of reasons. But whatever *your* reason, this you can be sure of: Whether your blood goes to a combat area, a local hospital, or for Civil Defense needs— this priceless, painless gift will some day save an American life!

Give Blood Now

CALL YOUR RED CROSS TODAY!

NATIONAL BLOOD PROGRAM

Business Executives!

✓Check These Questions!

If you can answer "yes" to most of them, you—and your company—are doing a needed job for the National Blood Program.

- ☐ Have you given your employees time off to make blood donations?
- ☐ Has your company given any recognition to donors?
- ☐ Do you have a Blood Donor Honor Roll in your company?
- ☐ Have you arranged to have a Blood-mobile make regular visits?
- ☐ Has your management endorsed the local Blood Donor Program?
- ☐ Have you informed employees of your company's plan of co-operation?
- ☐ Was information given through Plant Bulletin or House Magazine?
- ☐ Have you conducted a Donor Pledge Campaign in your company?
- ☐ Have you set up a list of volunteers so that efficient plans can be made for scheduling donors?

Remember, as long as a *single* pint of blood may mean the difference between life and death for *any* American . . . the need for blood is *urgent!*

Don't Worry About Nuts In Hard-To-Get-At Places

use

MIDLAND
Welding Nuts

THIS IS ALL YOU DO—Just insert collar of Midland Welding Nut in hole for bolt or screw, resistance weld the Nut in place, and the *nut is there for the life of the job.* Nuts can be automatically fed to the welder. No time wasted or trouble screwing-on nuts in hard-to-get-at places. Write for facts about these better connections at *less cost.*

The MIDLAND STEEL PRODUCTS COMPANY

6660 Mt. Elliott Ave. • Detroit 11, Michigan

Export Department: 38 Pearl St., New York, N. Y.

Manufacturers of

AUTOMOBILE AND TRUCK FRAMES | AIR AND VACUUM POWER BRAKES | AIR AND ELECTRO-PNEUMATIC DOOR CONTROLS

AVAILABLE

to fill vacancies in your plant....

DESIGN ENGINEERS

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ELECTRICAL ENGINEERS

MECHANICAL ENGINEERS

EXPERIMENTAL ENGINEERS

DEVELOPMENT ENGINEERS

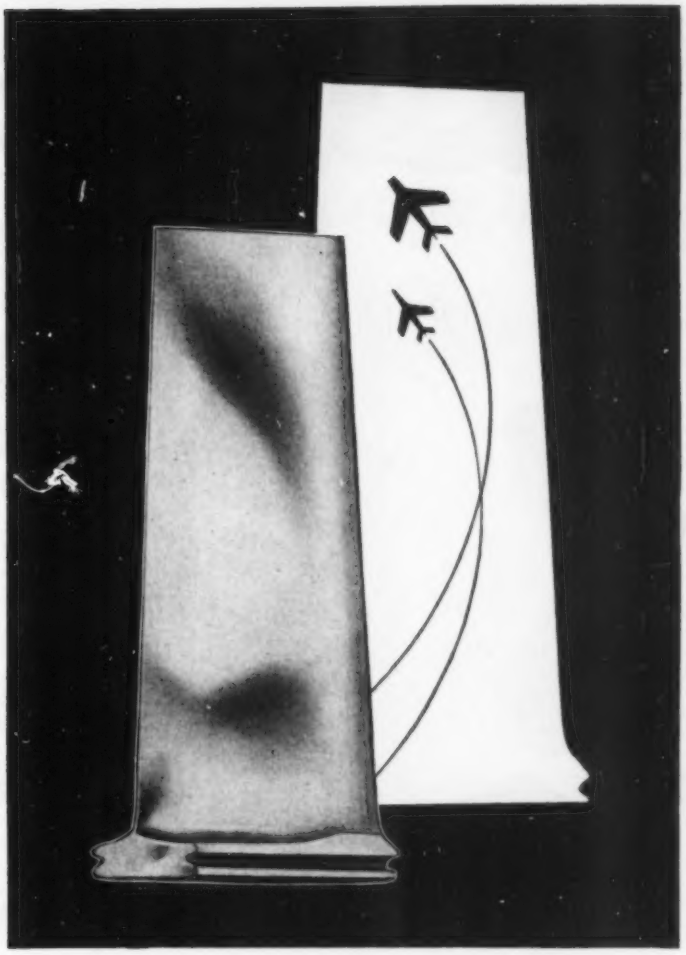
METALLURGICAL ENGINEERS

CHIEF DRAFTSMEN ..... and ASSISTANTS

They are the readers of this publication. You can secure their services by advertising where they will see it—in our classified advertising section starting on page 449 in this issue.

Copy must be received at 330 W. 42nd St., N. Y. 36, N. Y. by March 16th to be in the April issue.

PRODUCT ENGINEERING



UTICA HELPS

BY FORGING THE "NEW" HARD-TO-HANDLE METALS

Flooding from UTICA production lines come forged turbine and compressor blades for jet engines, produced complete from metal stock to finished part. Made from the new super-hard metals, it's an exciting and exacting job calling for pioneering in forging metallurgy.

This is one sample of our custom forging work—which includes experience in the "new" metals...high-temperature alloys; the Nimonics, S-816, Waspalloy, Titanium and others.

At UTICA we combine 57 years of forging know-how with the most modern methods and finest equipment... sparked by a continuous drive for ever finer quality.

Send for your copy of "File Facts on Precision Forgings," which outlines UTICA's *methods and facilities now engaged in jet blade production but ultimately generally available.*

PRECISION····
U TI CA
····FORGINGS

UTICA DROP FORGE & TOOL CORPORATION, Utica 4, New York

MAKERS OF THE FAMOUS LINE OF UTICA DROP FORGED PLIERS AND ADJUSTABLE WRENCHES

Purebon

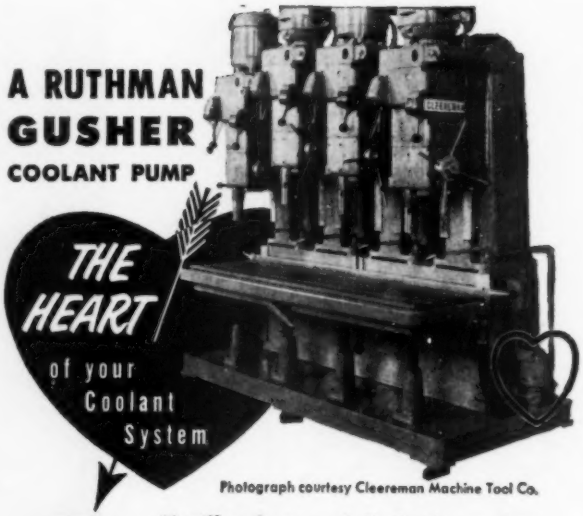
SOLVES MANY PROBLEMS
caused by sliding or rotating parts which are DIFFICULT OR IMPOSSIBLE TO LUBRICATE

A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machinable and in many cases can be molded directly to size.

Bulletin No. 52 tells the complete story of Purebon. Write for your copy today.

PURE CARBON CO., INC.
448 HALL AVE. ST. MARYS, PA.

A RUTHMAN GUSHER COOLANT PUMP



Photograph courtesy Cleereman Machine Tool Co.

You'll go far toward eliminating coolant troubles on your machines when you *specify* Gusher Coolant Pumps. Gushers are precision built! All rotating parts are electronically balanced. Maintenance costs are cut to a minimum. Illustrated is a Model 325 Cleereman Four Spindle Drilling Machine with a Model UL-2106 Ruthman Gusher Coolant Pump.

THE RUTHMAN MACHINERY CO.
1818 Reading Road Cincinnati, Ohio

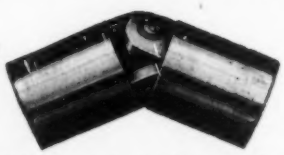
FOUR TYPES OF···
WOVEN BRAKE LINING
COVERING ALL INDUSTRIAL REQUIREMENTS FOR INTERNAL AND EXTERNAL BRAKES

sizes 1 1/2 x 5/32" through 4 x 3/8"
LARGE CAPACITY (10,000 ft. per Day)
LONG EXPERIENCE (since 1927)
SPECIALISTS IN SHORT RUN ORDERS
WE INVITE YOUR INQUIRIES

SOUTHERN FRICTION MATERIALS CO.
CHARLOTTE, N.C., U.S.A.

ATLAS *HIGH* or LOW SPEED **UNIVERSAL JOINTS**

IMPROVE YOUR PRODUCT...
REDUCE YOUR COSTS...



GRAY & PRIOR

Quotations and detailed Catalog available on request. Write today!

THE GRAY & PRIOR MACHINE CO.
623 WINDSOR ST. HARTFORD, CONN. U.S.A.

CONTINENTAL AIR FILTERS, Inc. STANDARDIZES WITH OHIO STOCK GEARS AND REDUCERS

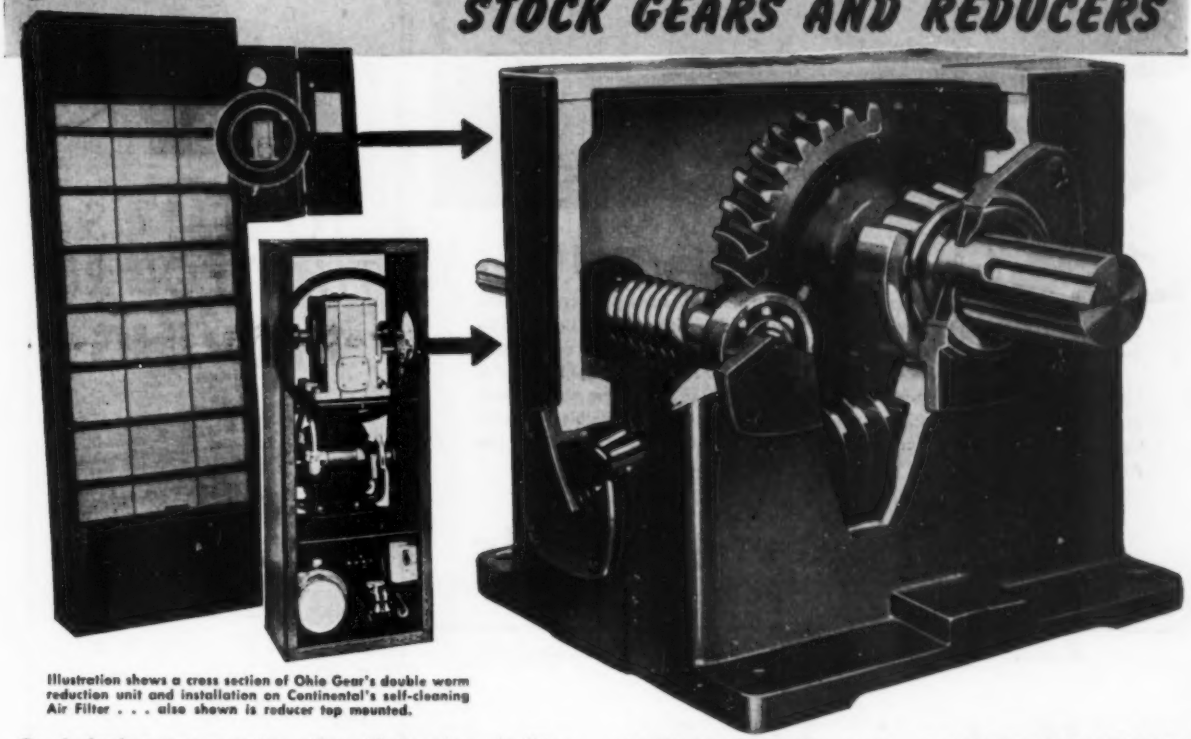


Illustration shows a cross section of Ohio Gear's double worm reduction unit and installation on Continental's self-cleaning Air Filter . . . also shown is reducer top mounted.

In designing a new automatic self-cleaning air filter, Continental Air Filters, Inc. of Louisville, Ky., gave careful consideration to the known short-comings of existing automatic filters. Continental made exhaustive studies of all accessories to the filter, and for reasons of sound engineering design, dependable and accurate performance, reputation and physical impactness, an Ohio Gear reducer was chosen. Just as industry depends on Continental Air Filter for the important function of keeping the air clean, so does Continental depend on Ohio Gear for accurate and consistent performance of their unit. This was an important factor in the largest installation of automatic self-cleaning filters under roof, the Ford Motor Company's Foundry, at Cleveland, Ohio. Continental considers the dependable operation of Ohio Gear reducers partially responsible for its success. Perhaps Ohio Gear can serve you as well. Get in touch with their nearest distributor or write direct to THE OHIO GEAR COMPANY, 1325 East 179 Street, Cleveland 10, Ohio.

ESTABLISHED 1915

OHIO GEARS

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Hardware & Supply Co.
*Baltimore, Md.
L. A. Benson Co., Inc.
*Brooklyn 6, N. Y.
(Gears) Northside Leather Belting Co., Inc.
Buffalo, N. Y.
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*S. H. Pooley Belting Co.
*Chicago 23, Illinois
Apex Power Equipment Co.
*Chicago 7, Illinois
Schrade-Batterson Co.
*Cincinnati 14, Ohio
Metzger Machine Co.
*Cleveland 2, Ohio
J. A. Shomer Co.
*Cleveland 10, Ohio
Ohio Gear Co.
Dayton, Ohio
E. C. Hawk
*Detroit 2, Michigan
Abrasive and Supply Co.
*Erie, Pennsylvania
Cohen Auto Parts Co., Inc.
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Bearing & Transmission Co.
*Grand Rapids 2, Mich.
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Behring's Bearing Service, Inc.
*Indianapolis, Indiana
A. R. Young
*Kansas City 16, North, Mo.
Sesco Engineering & Supply Corp.
*Los Angeles 21, Calif.
J. W. Minder Chain & Gear Co.
Louisville 2, Ky.
Alfred Halliday
*Massillon, Ohio
Hardware & Supply Co.
*Memphis 2, Tenn.
Memphis Bearing & Supply Co.
*Miami 9, Fla.
General Equipment & Supply, Inc.
Milwaukee 11, Wisc.
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*Minneapolis, Minn.
Industrial Supply Co.
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Lakeshore Machinery & Supply Co.
*New Orleans, La.
(Gears) R. J. Tricon Co.
(Reducers) Woodward Wight & Co., Ltd.
*New York, N. Y.
(Reducers) Patron Transmission Co.,
(Gears) Atlantic Gear Works
*Paterson 4, N. J.
(Gears) Bernstein Bros. Inc.
Pawtucket, Rhode Island
George G. Pragat
*Philadelphia, Pa.
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Bornell Supply Co., Inc.
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The Esmueller Co.
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U. and S., Inc.
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G. & J. Bearings & Supply Co.

IN CANADA, *Montreal, Quebec, John Braidwood & Sons, Ltd.
*Stocks Carried.

Partially wound bobbin-type coil

Here at Coto-Coil . . .

. . . bobbin type coils are produced in mass production quantities . . . yet with craftsman-like precision . . . to rigid specifications. In this battery of Bobbin Winders notice that each machine winds three coils simultaneously. The winding speed is timed so that two coils are winding at all times while the operator resets the third. Such modern production facilities, plus 35 years of experience, combine to make Coto-Coils the first choice for engineered coils. Coto-Coils Company, 61 Pavilion Avenue, Providence 5, R. I.

Coto PRECISION WOUND **Coils**

Mechanical Designers Layout Draftsmen

For PERMANENT POSITIONS with

Endicott, N. Y. **IBM** *Poughkeepsie, N. Y.*

TRADE MARK

Excellent opportunities for designers and layout draftsmen with a minimum of five years' experience desirable in mechanism design. Assignments involve the design and layout of intricate high speed mechanisms and electro-mechanical devices at both the development and production engineering level.

Good salaries, unusual opportunities for professional development, exceptional employee benefits, excellent working and living conditions, moving expenses paid.

Write, giving full details, including experience and training, to: Mr. W. M. Hoyt, Coordinator of Engineering Recruitment, International Business Machines, Dept. 686 (7), 590 Madison Avenue, New York 22, N. Y.

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On or about ..... my new address will be:

Street .....

City ..... Postal Zone #... State .....

Signed .....

My old address is:

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Let your imagination take wings on L·O·F Super·Fine Fiber·Glass

Just a little imagination . . . that's all it takes, and you can find any number of practical uses for L·O·F Super·Fine Fiber·Glass to profit you and your product.

Starting with Fiber·Glass . . . millions of tiny glass fibers held together by special binders to form lightweight insulating blankets . . . designers and engineers uncovered countless applications. Here are a few: components for rockets, protective wraps for frozen food, blackboard erasers, thermal curtains for greenhouses and the list goes on and on.

Check the outstanding properties of Super·Fine Fiber·Glass, relate them to your problem and let your imagination take wings.

Deadens sound. L·O·F Super·Fine Fiber·Glass is excellent acoustical insulation for middle- and high-frequency sound levels. It is highly flexible and can be fitted to irregular contours and shapes.

Prevents heat transfer. Super·Fine is superior to any inorganic fibrous insulation in its resistance to heat flow. The glass fibers will not burn, absorb moisture, mildew or rot.

Light as a feather. One square foot of Super·Fine Fiber·Glass, of a ¾-pound density and one-inch thickness, weighs only one ounce. It is easily cut with scissors, knife or roller cutter.

Supplied by a great name in glass. Libbey·Owens·Ford, long famous for outstanding glass products, assures you of top-quality Fiber·Glass delivered to your specifications right on schedule.

L·O·F Super·Fine Fiber·Glass can serve you or your product. Contact your nearest L·O·F office (offices in 26 major cities). Or write Libbey·Owens·Ford, Dept. F.G 433 Wayne Building, Toledo 3, Ohio.

LIBBEY·OWENS·FORD GLASS COMPANY
FIBER-GLASS DIVISION

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51 INDIVIDUAL INSPECTIONS . . .

Every Motor must meet rigid test for instant starting with full power capacity

AND GRUELING LABORATORY TESTS INSURE THE

ACCURACY and DEPENDABILITY of

SYNCHRON® timing motors

There's no guess-work in the manufacture of SYNCHRON timing motors and timing machines. 51 separate inspections and tests determine the final fitness of each motor before it leaves the factory. These tests, plus advanced engineering and carefully selected materials, assure SYNCHRON accuracy and dependability.

Pulls up to 8 oz. direct load at 1 R.P.M.

timing machines

— engineered for easy adaptability, powered by tested SYNCHRON motors-complete, ready to install in any timing device.

Operates efficiently at −40° to +140°F. Available with gear trains for any speed.

Mail coupon or engineering data

HANSEN MANUFACTURING CO., INC., Princeton 5, Ind.
Send catalog and engineering data to:

Name .....
Firm .....
Address .....
City ..... Zone .... State .....

So VITAL,—*yet* So "unsung" . . .

. . . is the role of Bronze Castings in the manufacture of many industrial machines or products. So often, they are "taken for granted",—yet they are often the very foundation upon which the *Quality* and *Performance* of the finished product depends.

Seldom does the *Foundry's name* appear upon the casting,—so the final user of the finished machine or product *never knows* who *makes* that important part. . . . Thus, it is truly *vital* when you buy Bronze Castings, that you be *sure* of the ability, experience and reputation of the Foundry to deliver just what *you need and desire.*

Please send me a copy of your latest "Reference Book of Bronze Casting Alloys."

AMERICAN MANGANESE BRONZE COMPANY

4705 Rhawn St., Holmesburg, Philadelphia 36, Pa.

Established 1909

ENGINEERS:

We've Got what you're Looking for!

T. H. Beck, Manager of Engineering. Is an engineering veteran of over 22 years in the aviation and related industries.

A secure future, exceptional opportunities for advancement, and a high starting salary await you at FAIRCHILD. We have openings right now for qualified engineers and designers in all phases of aircraft manufacturing; we need top-notch men to help us in our long-range military program: turning out the famous C-119 Flying Boxcar and other projects for the U.S. Air Force.

FAIRCHILD provides paid vacations and liberal health and life insurance coverage. We work a 5-day, 40-hour week as a base. Premium is paid when longer work week is scheduled.

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD *Aircraft Division*
HAGERSTOWN, MARYLAND

TIN DECONTROLLED

NOW Tin May Be Purchased

By Any User—in Any Quantity—for Any Purpose

For the first time since early in 1951, tin is free of U.S. Government controls as to use, stocks and shipment. On February 6 the National Production Authority removed all restrictions on this vital metal.

The only Government requirement remaining is that tin consumers and dealers submit monthly reports on their stocks, receipts, shipments and consumption.

This new order means that now tin may be purchased by *any* user—in *any* quantity—for *any* purpose.

It means that one of the world's most important metals is again freely available to American industry.

The NPA announcement says in part:

> The supply of tin contracted for and otherwise obtainable in world markets for use in this country now is sufficient to balance against demands, both Government and civilian.

TIN IS VITAL—The tin producers of Malaya, principal source of the world's supply, welcome removal of controls that have misled American industry into a wasteful and costly search for substitutes for tin.

Tin is vital to the security of the United States, Malaya and the Free World.

Tin is vital to the economy of the United States, Malaya and the Free World.

Just as the United States and Malaya are allies in defense of the Free World, so are they partners in tin. And by gaining the offensive in its war against Communist guerrillas, Malaya has materially strengthened its position as the world's most important supplier of tin for the needs of the United States.

• • •

To supply accurate information about tin and to report on new developments, we publish a monthly newsletter. Write now for the current issue of "Tin News" with important supplement on the official NPA announcement.

THE MALAYAN TIN BUREAU
Department 462
1028 Connecticut Avenue **Washington 6, D.C.**

There is No Real Substitute for Tin

". . . free as a nation and financially independent as individuals."

OLIVER P. ECHOLS

Chairman of the Board, Northrop Aircraft, Inc.

"For nearly every American, systematic saving during productive years is the best means of insuring future security. We at Northrop Aircraft believe in the Payroll Savings Plan. We feel that bond purchases contribute greatly toward keeping us free as a nation and financially independent as individuals."

In addition to a deep, personal interest in his own company's Payroll Savings Plan, Mr. Echols is Chairman of the Aircraft Industry Committee to build employee participation in the Payroll Savings Plan.

- When Mr. Echols' Committee was formed, 17 major airframe manufacturers and 11 major suppliers, employing 400,000 workers, had a total of 80,000 employees enrolled in the Payroll Savings Plan.
- At Mr. Echols' request all 28 companies agreed to conduct person-to-person canvasses among their employees.
- The first companies to complete their canvasses report a total of more than 70,000 new Payroll Savers bringing the industry total to more than 150,000 participants.
- In the first reports on campaigns, average payroll participation (companies reporting) went from 20% to 32%. Latest indications are that the average participation—all 28 companies—will be well over 50% by the time the canvasses are completed.
- It is estimated that the 70,000 new Payroll Savers already added to the Plan through the co-operation of Mr. Echols and his Committee will purchase more than 15 million dollars worth of Series E Defense Bonds during the next twelve months.

Has *every* employee of your company been offered an opportunity to enroll in the Payroll Savings Plan? If not, phone, wire or write to Savings Bond Division, U. S. Treasury Department, Suite 700, Washington Building, D. C. Your State Director will help you conduct a person-to-person canvass.

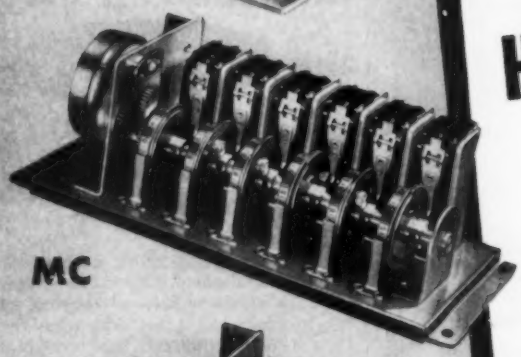
Typical Companies Reporting Results of Person-to-Person Canvasses, Payroll Savings Plan.

	Before Canvass	After Canvass
Hughes Aircraft	38.7%	85.8%
Continental Motors	10%	70%
Boeing Aircraft	17.8%	55.1%
Rohr Aircraft	1.3%	77.6%
Solar Aircraft	1.8%	60.5%
Bell Aircraft	14%	50%

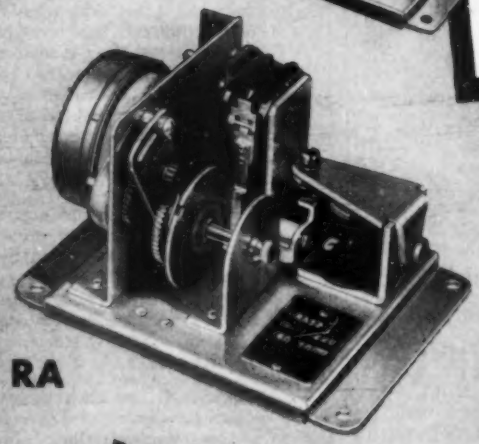
The U.S. Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

Product Engineering

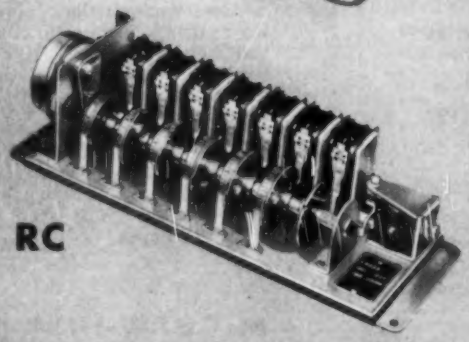
CM



MC



RA



RC

These Industrial Timer Corporation timers provide accurate and highly dependable instruments for control of a single operation or multiple operations (simultaneously or in sequence).

OUTSTANDING FEATURES ARE:

(1) the wide range of over-all time cycles obtainable from any one model;

(2) the ease with which over-all time cycles can be changed;

(3) the simplicity with which individual cams can be adjusted for ON and OFF periods, and positioned in specific timing sequence.

Highly Dependable

Synchronous Motor Driven

Cam Timers

Series CM CAM RECYCLING TIMERS

The Series CM Cam Recycling Timer repeats a definite electrical ON and OFF time cycle continuously. The cam is coupled to the motor by means of a simple gear and rack assembly—and the over-all time cycle can be easily changed by substituting gear racks. (Bulletin 33)

Series MC MULTI-CAM TIMERS

The Series MC Timer is identical to the CM Timer, but operates 2 to 6 circuits. All cams are mounted on a single shaft, which assures a common time cycle for all circuits. Each cam, however, is independently adjustable for a specific timing sequence. (Bulletin 34)

Series RA SINGLE CYCLE CAM TIMERS

The Series RA Timer provides a single time cycle upon being actuated electrically from remote control. A pawl on the cam eliminates necessity for prolonged closing of relay switch when starting. (Bulletin 35)

Series RC SINGLE CYCLE MULTI-CAM TIMERS

The RC is identical to the RA, but operates from 1 to 6 additional circuits. Thus it provides all the features of the Series MC Timer, plus the single cycle control afforded by the RA. (Bulletin 35)

Send us specifications, and we shall make recommendations based on your particular needs. Bulletins sent free on request.

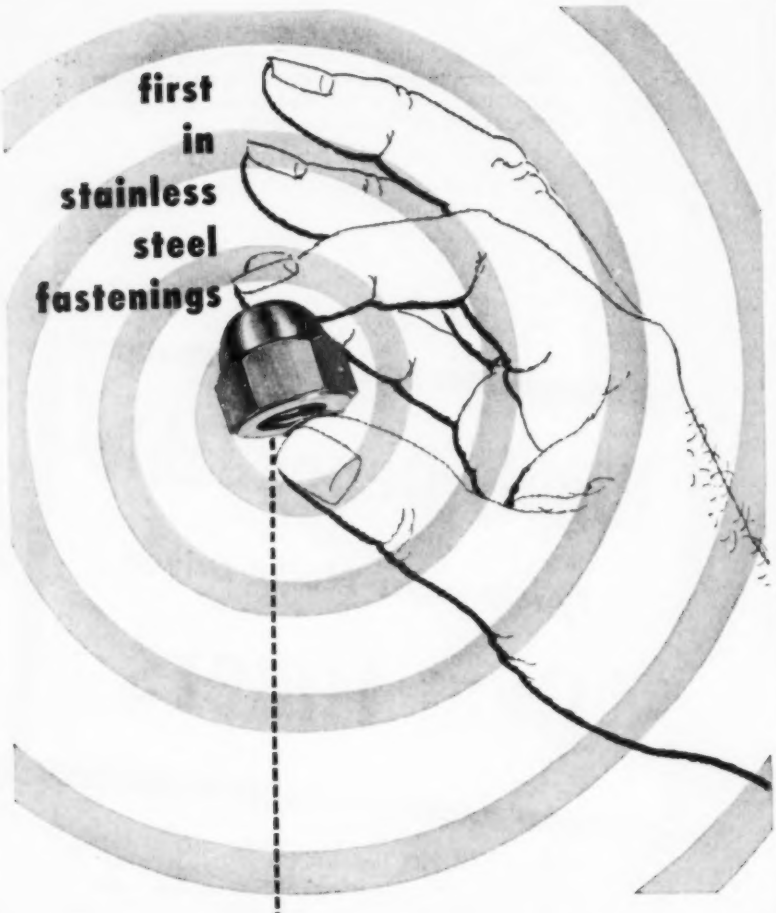
MANUFACTURERS OF THESE AND OTHER TIMERS AND CONTROLS FOR INDUSTRY— Time Delay Timers • Manual Set Timers • Tandem Automatic Recycling Timers • Running Time Meters • Instantaneous Reset Timers

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION

115 EDISON PLACE, NEWARK 5, N. J.



INDUSTRIAL buyers have learned to depend on ANTI-CORROSIVE for fast, dependable service on all types of stainless steel fastenings. Draw on our IN STOCK inventory of more than 7,000 items and sizes and a production capacity geared to produce precision fastenings in large or small quantities, from huge 7/8" hexagon head bolts to tiny #0-80 machine screw nuts.

Write for Catalog 53M today.

anti-corrosive metal products co., inc.
castleton-on-hudson, new york

How to keep informed on the "with what" part of your business

AT YOUR FINGER TIPS, issue after issue, is one of your richest veins of job information—advertising. You might call it the "with what" type—which dovetails the "how" of the editorial pages. Easy to read, talking your language, geared specifically to the betterment of your business, this is the kind of practical data which may well help you do a job quicker, better—save your company money.

Each advertiser is obviously doing his level best to give you helpful information. By showing, through the advertising pages, how his product or service can benefit *you* and *your* company, he is taking *his* most efficient way toward a sale.

Add up all the advertisers and you've got a gold mine of current, on-the-job information. Yours for the reading are a wealth of data and facts on the very latest in products, services, tools . . . product developments, materials, processes, methods.

You, too, have a big stake in the advertising pages. Read them regularly, carefully to keep job-informed on the "with what" part of your business.

McGRAW-HILL PUBLICATIONS

CLASSIFIED SEARCHLIGHT SECTION ADVERTISING

EMPLOYMENT • BUSINESS • OPPORTUNITIES • EQUIPMENT—USED or RESALE

UNDISPLAYED RATE

$1.50 per line, minimum 3 lines. To figure advance payment, count 5 average words as a line.

(See ¶ on Box Numbers.)

POSITION WANTED & INDIVIDUAL SELLING OPPORTUNITY WANTED undisplayed advertising rate is one-half of above rate, payable in advance.

PROPOSALS $1.50 a line an insertion.

INFORMATION

BOX NUMBERS care publication count as 1 line additional in undisplayed advertisements. DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals.)

EQUIPMENT WANTED OR FOR SALE Advertisements acceptable only in Displayed Style.

DISPLAYED RATES

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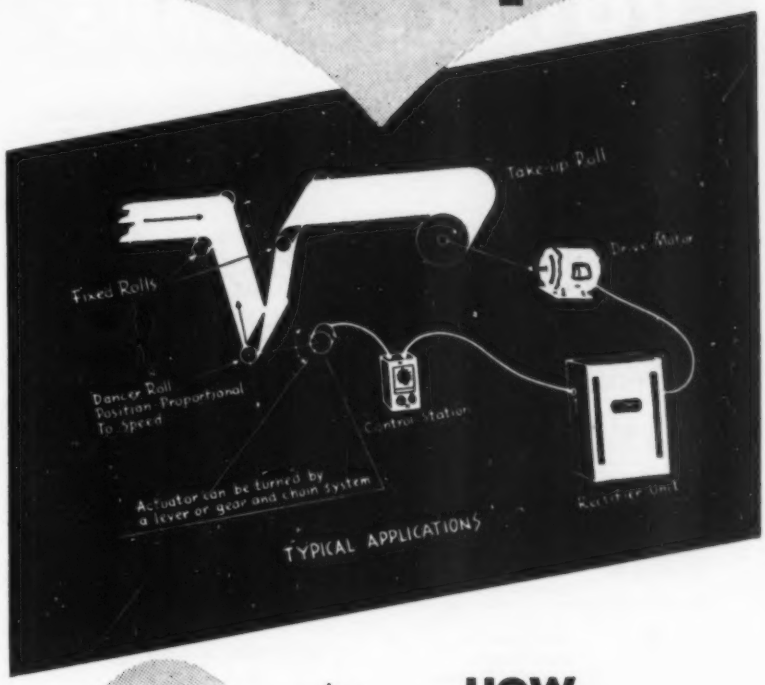

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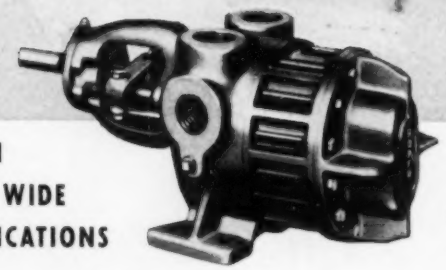

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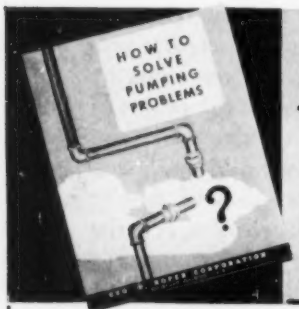

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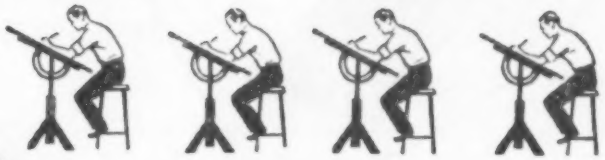

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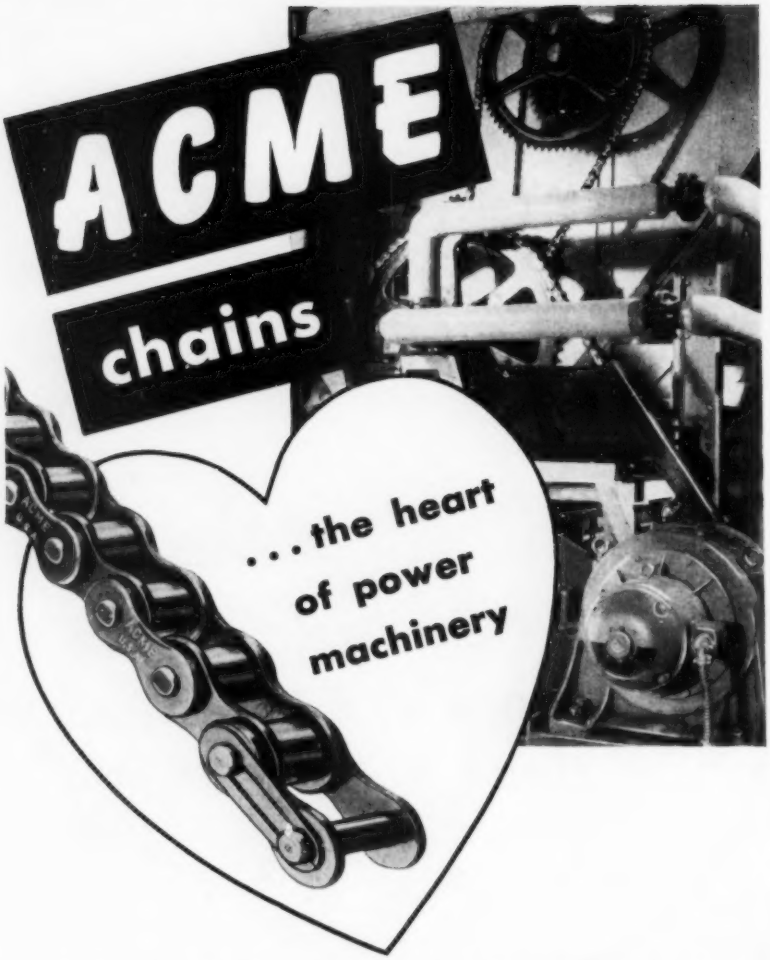

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Write Dept. 1E for new illustrated 76 page catalog on use and application of roller chains and sprockets.

Acme Chain Corporation
HOLYOKE
MASSACHUSETTS

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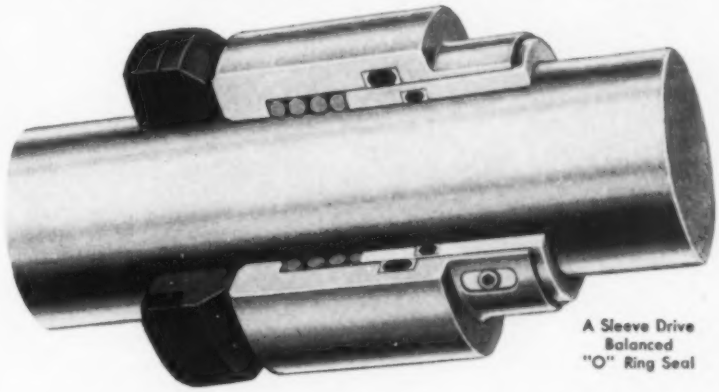
Garlock "O"-Ring Seals

FOR ROTATING PUMP SHAFTS



A Sleeve Drive Balanced "O" Ring Seal

Simple in Design, Leakless in Operation

GARLOCK "O" Ring Mechanical Seals are made with a minimum of parts. This simplicity of design affords easy manufacturing adaptability of a Garlock "O" Ring Seal to withstand any liquid, whether mild, harmfully corrosive or extremely hazardous, on rotating pump shafts. The Garlock "O" Ring Balanced Seal will hold pressures up to and over 1000 p.s.i.

The "O" rings are available in "Teflon," Buna-N, Neoprene or Silicone. The metal parts contacting the liquid are available in any suitable metal.

On centrifugal pumps handling chemicals, petroleum products, edible liquids, pulp liquors, and many other liquids Garlock "O" Ring Mechanical Seals are giving outstanding service.

For positive sealing, easy installation and trouble-free service use Garlock "O" Ring Mechanical Seals on your rotating pump shafts. Write us about your sealing problems or contact your Garlock representative.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

In Canada:
The Garlock Packing Company of Canada Ltd., Toronto, Ont.

GARLOCK

PACKINGS, GASKETS, OIL SEALS
MECHANICAL SEALS
RUBBER EXPANSION JOINTS

HYDRECO
Oil Power

Bends Giant Elbow

Heavy-duty "Backhoe", manufactured by Ottawa Steel Products, Inc., Ottawa, Kansas, digs trenches and square holes up to 36" wide x 8½' deep. Hydraulic-actuated "elbow" reaches out over 15', can swing in arc of 130°. Four operations are handled by two control levers.

With the ingenious Ottawa "Backhoe", ditch-digging is a cinch. This device was built for speed, accuracy and endurance in digging square holes, trenches, ditches, graves on level or hilly terrain. Its power is hydraulic, co-designed by Ottawa and Hydreco engineers. The complete system consists of:

7 Hydreco cylinders to actuate leveling jacks, swing jacks, and operation jacks,
1 Hydreco pump, and
2 Hydreco control valves.

Let Hydreco engineers work with you on hydraulic control problems for your equipment. Write for folder on Hydreco Pumps, Motors, Valves and Cylinders.

HYDRECO A DIVISION OF THE NEW YORK AIR BRAKE CO.

1112 EAST 222nd STREET • CLEVELAND 17, OHIO

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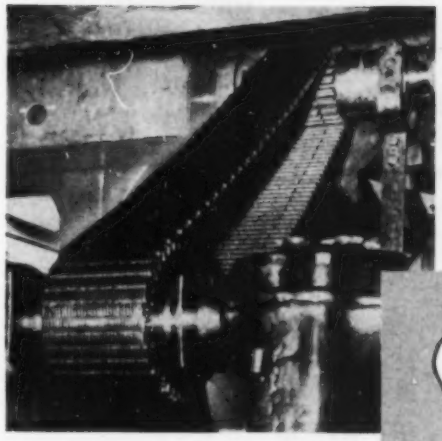


One of six Ramsey Chain Drives on the presses of a large New York City newspaper, successfully meeting daily peak demands in speed and continuous operation.

RAMSEY
SILENT CHAIN DRIVE

Every joint has the smoothness of a roller bearing

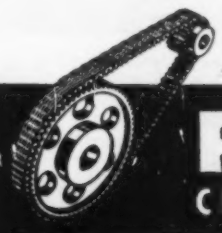
You get far more than silence in a drive like this.

You get a smooth flow of power, due to the patented roller bearing joint (above right), built into every link of a Ramsey Chain. No matter how heavy the load, or how fast you run it, you get freedom from friction in the Ramsey Chain.

Ramsey joint action cuts down heat generated at high speeds usually found in conventional chain joints; reduces wear and, gives long chain life. You get more power, too, because a smooth running Ramsey Chain transmits ALL the power—does not consume it. Moreover, you get a chain drive unlike any other make, in that its anti-friction features permit the use of only a minimum of lubrication. Oil pumps and slingers are unnecessary.

FREE APPLICATION MANUAL FOR ENGINEERS

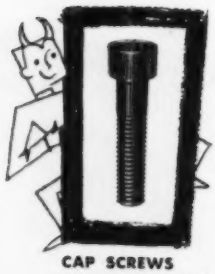
This 60 page book gives you the range and scope of Ramsey Silent Chain Drives—tells you how to work out applications and includes the necessary data on chains, sprockets and pinions. Write for a copy today.



SILENT CHAIN DRIVES – FLEXIBLE COUPLINGS

RAMSEY
CHAIN COMPANY, INC.
5150 BROADWAY • ALBANY, N. Y.

"QUINTS" FOR QUALITY



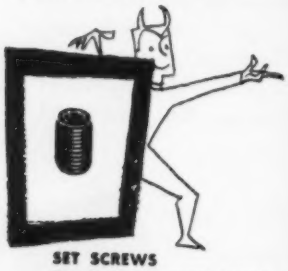
CAP SCREWS
"Diagonal Knurl" heads —a Triple-Ess exclusive—end finger fumbling in hand assembly. Precision Class 3 fit.

STRIPPER BOLTS
Accurately ground body diameters, undercut to permit tightening flush to shoulder. Stronger, longer wearing.

FLAT HEAD CAP SCREWS
Flush-type for use with countersink. Tamper-proof, eliminate stripped slots. Precision Class 3 fit.

SOLD ONLY THROUGH AUTHORIZED INDUSTRIAL DISTRIBUTORS

PIPE PLUGS
No protruding heads. Precision threads assure an excellent dry seal. Threads cut to close tolerances.

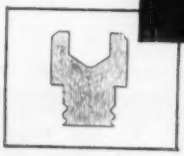


SET SCREWS
Supplied with ground threads whenever screw length equals or exceeds diameter. Six point styles.

Blue Devil

SOCKET SCREW PRODUCTS

SOCKET SCREWS EXCLUSIVELY!



Actual cross-section photo shows how cold forming of Blue Devil socket head insures unimpaired fiber continuity.

SAFETY SOCKET SCREW COMPANY

6504 Avondale Avenue, Chicago 31, Illinois

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(*Classified Advertising*)
H. E. Hilty, Mgr.)

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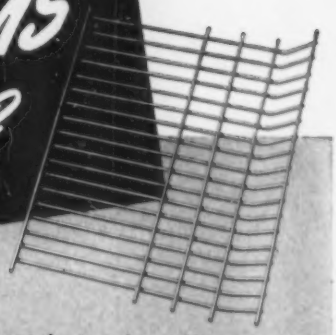


Had to Conserve Steel

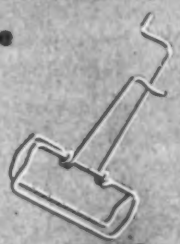
Ice deflector assembly made by Company A for ice cube machines consisted of sheet steel, woven wire cloth and steel frame. Material shortages loomed. Told it to Titchener. Titchener designed this welded wire rack using one size of wire. New assembly proved to be sturdier — rustless — lower in cost. Additional dividends: simple tooling — fast large-scale production.
Note: Wire is more readily available during shortages. Can your product be made of wire? Ask Titchener.

Wanted Substitute for Casting

Company B, a stove manufacturer, was dissatisfied with breakage of its cast iron burner grates. Told it to Titchener. This Titchener welded-wire assembly was substituted. Result: No breakage — costs less.
Note: Wire is rigid, yet resilient. Light, yet tough. Stronger than castings or forgings. Wondering if wire can help you? Ask Titchener.

Design Was Difficult to Produce

Company C designed this complicated two-piece floor mop wire clamp. Ran into production difficulties. Told it to Titchener. Our skilled tool makers developed an ingenious method of coiling wire around itself. This made it possible to produce thousands of precision-made clamps at high speed on Titchener's forming machines.
Note: Titchener has worked hand in glove with all types of industry — large and small — in peace and war — for 65 years. How can Titchener serve you?



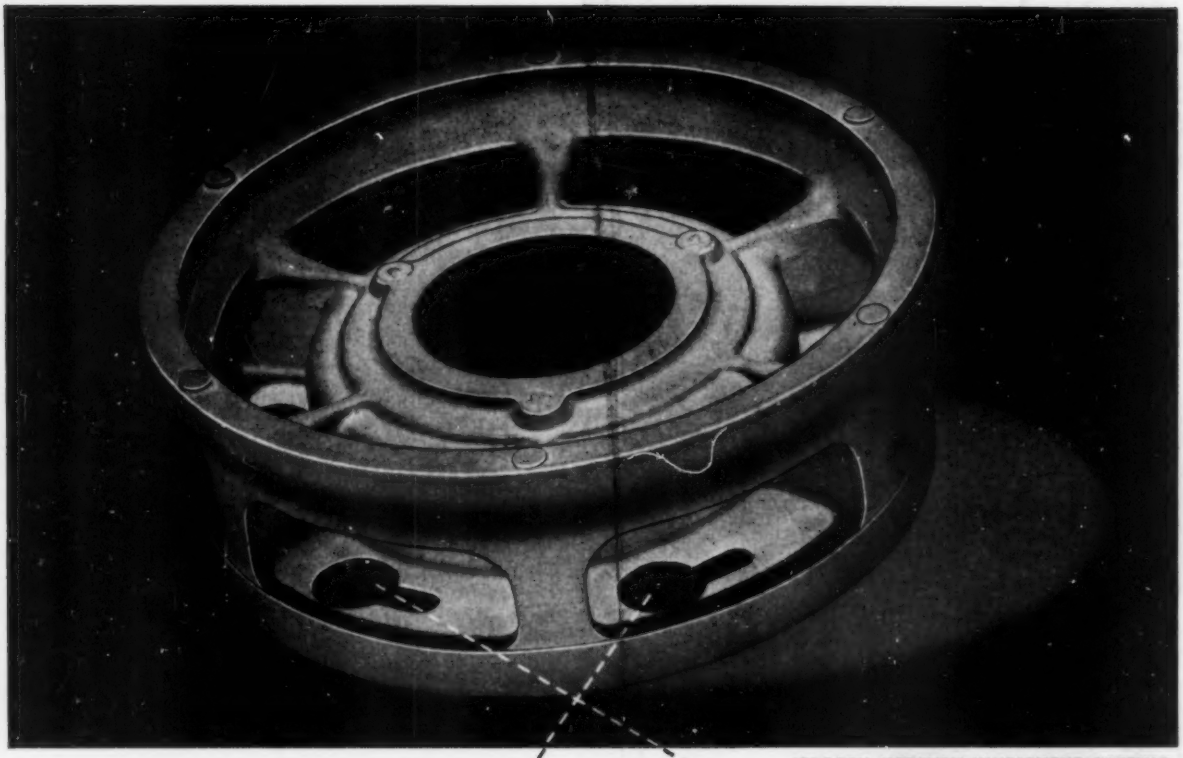
Tell it to TITCHENER!

If your problem involves wire forms, light stampings, welded-wire assemblies or wire-and-strip-steel items — Tell it to Titchener.

Titchener offers you . . .
- Design Assistance
- Tool and Jig Making
- High Volume Production
- Plating and Finishing
- Sample Making
- Quickly Available Materials
- Careful Inspection
- Prompt Delivery

Send us your prints — or describe your problem in a letter. Confidential. No charge for our suggestions.

E. H. TITCHENER & CO.
103 CLINTON ST. BINGHAMTON, N.Y.



*FROZEN MERCURY INVESTMENT CASTING

MERCAST* Buttonholes

BUTTON A GENERATOR on or off of an airplane? Westinghouse does! And at a reported time saving of up to 8 man-hours per plane!

The ingenious new Westinghouse generator mounting bracket employs "buttonholes" that permit the assembly to be quickly slipped on or off over headed studs on the airframe. For practical production of this unit, a one-piece precision casting to close dimensional and surface tolerances is the economical answer. This casting, however, is much larger than can be produced by ordinary investment casting processes.

Westinghouse brought the problem to Alloy Precision Castings Company. Engineers and metallurgists at Alloy developed the illustrated 6 lb., 6½ inch diameter mercasting in 410 stainless. Critical tolerances are held to ±.003"/inch. Very little finish machining is required and the "buttonholes" are used as cast. Complete inspection by Alloy assures customers top quality and accuracy.

Mercasting made the Westinghouse generator mount idea a reality. Send details about your "impossible" or "too costly" jobs today! Learn how Alloy Precision can save you time and money with designs for mercasting.

A-9298

ALLOY PRECISION CASTINGS COMPANY, DEPT. C-2
45th and Hamilton, Cleveland 14, Ohio

Please RUSH Bulletin 706 describing the Mercasting Process.

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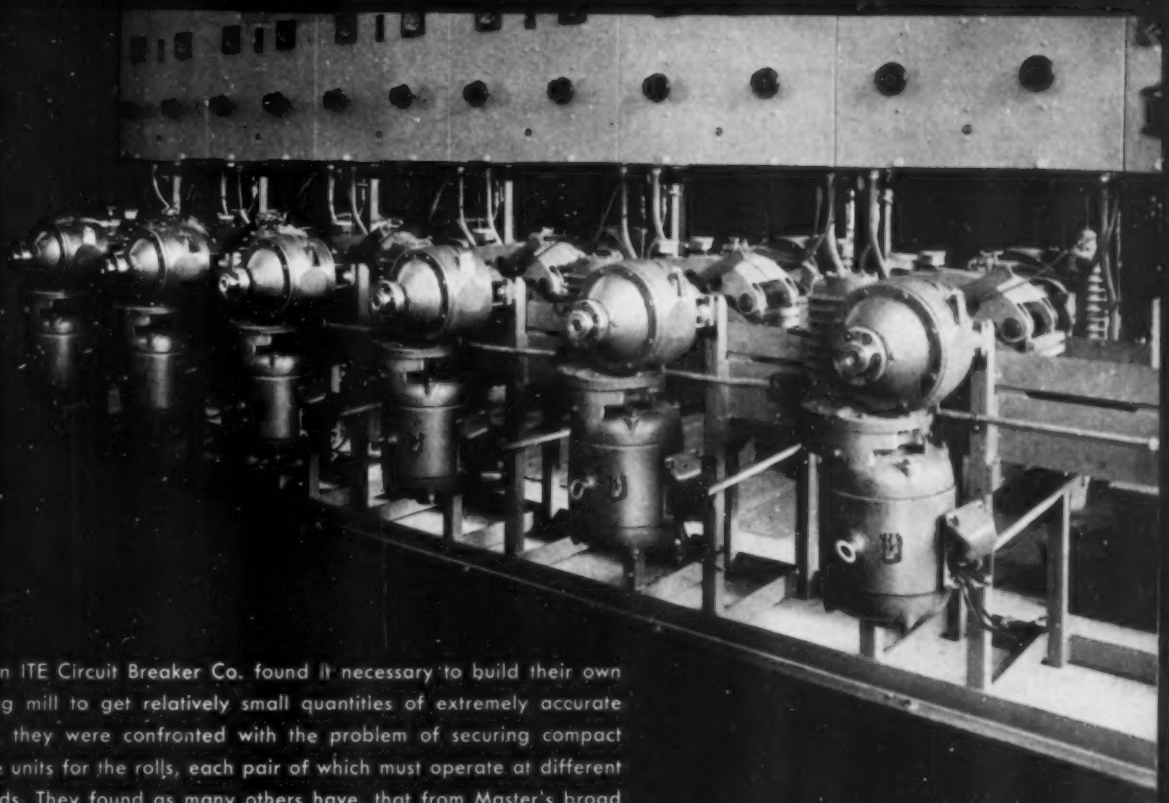
ALLOY PRECISION Castings Company

EAST 45th ST. AND HAMILTON AVE. • CLEVELAND 14, OHIO



When ITE Circuit Breaker Co. found it necessary to build their own rolling mill to get relatively small quantities of extremely accurate strip, they were confronted with the problem of securing compact drive units for the rolls, each pair of which must operate at different speeds. They found as many others have, that from Master's broad line of Gearmotors they could select standard units which would give them the RIGHT horsepower, the RIGHT shaft speed in one compact unit that they could use RIGHT where they wanted it.

Probably you will never design a rolling mill. But the next time you need motor drives for your plant or product, remember that Master Motors, available in thousands and thousands of types and ratings, give you a selection you can get nowhere else.

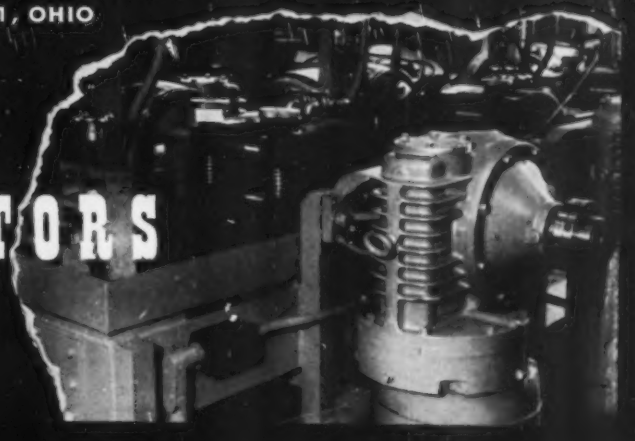
tough problem . . . easy solution

Open, enclosed, splash proof, fan-cooled, explosion proof . . . horizontal or vertical . . . for all phases, voltages and frequencies . . . in single speed, multi-speed and variable speed types . . . with or without flanges or other special features . . . with 5 types of gear reduction up to 432 to 1 ratio . . . with electric brakes . . . with mechanical variable speed units . . . and for every type of mounting . . . Master has them all and so can be completely impartial in helping you select the one best motor drive for YOU.

Select the RIGHT power drive from Master's broad line and you can increase the saleability of your motor driven products . . . improve the economy and productivity of your plant equipment.

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

MASTER GEARMOTORS



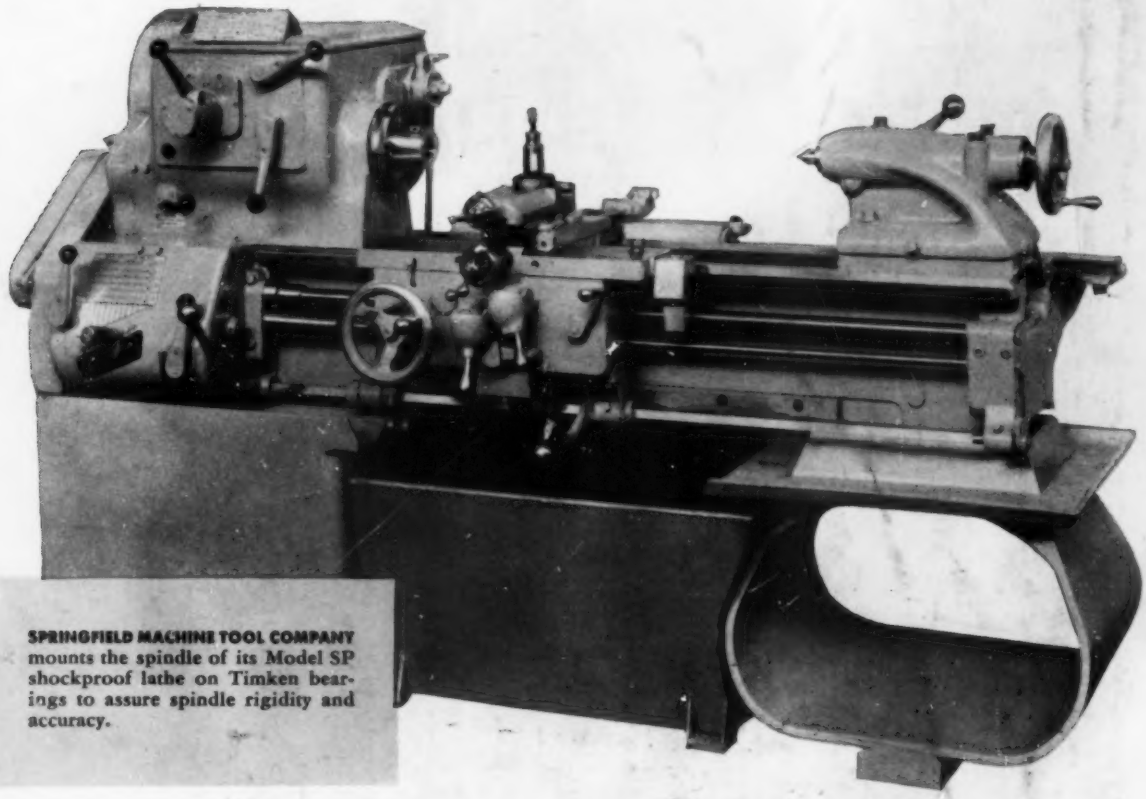
Sea-going lathe has sea legs for steadiness ...TIMKEN® bearings for precision

THIS new Springfield shockproof lathe is especially designed for high precision machine work while bolted to the deck of a naval vessel at sea. It has a radically different structure and special "sea legs" that prevent it from weaving when the deck flexes and enables the machine to withstand the severe shock of near misses and other combat-incurred stresses. Spindle rigidity and accuracy, essential for high precision work on land or sea, is maintained with Timken® precision tapered roller bearings.

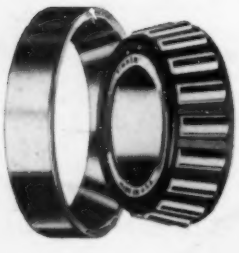
Timken precision bearings are especially designed for spindle applications. Run-out tolerances can be held to a maximum of 75 millionths of an inch. The tapered design of Timken precision bearings enables them to take both radial and thrust loads in any combination, holds spindles rigid and permits pre-loading to any desired degree to prevent chatter. Tapered design also makes Timken precision bearings easy and less costly to assemble (bench assembly is possible), and eliminates the need for special thrust bearings.

For the past 25 years, Timken precision bearings have been an important factor in the development of precision machine tools. Next time you buy or build a machine tool, be sure it's equipped with Timken precision tapered roller bearings. Always look for the trade-mark "Timken" stamped on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian Plant: St. Thomas, Ont. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



SPRINGFIELD MACHINE TOOL COMPANY mounts the spindle of its Model SP shockproof lathe on Timken bearings to assure spindle rigidity and accuracy.



TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

DESIGN LEADERSHIP

The first Timken tapered roller bearing was produced in 1898. Since then the one-piece multiple perforated cage, wide area contact between roller ends and ribs, and every other important tapered roller bearing improvement have been introduced by The Timken Roller Bearing Company.

The Timken Company leads in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis steels.

NOT JUST A BALL ◯ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▱ BEARING TAKES RADIAL ▯ AND THRUST ⊣▯⊢ LOADS OR ANY COMBINATION ✳